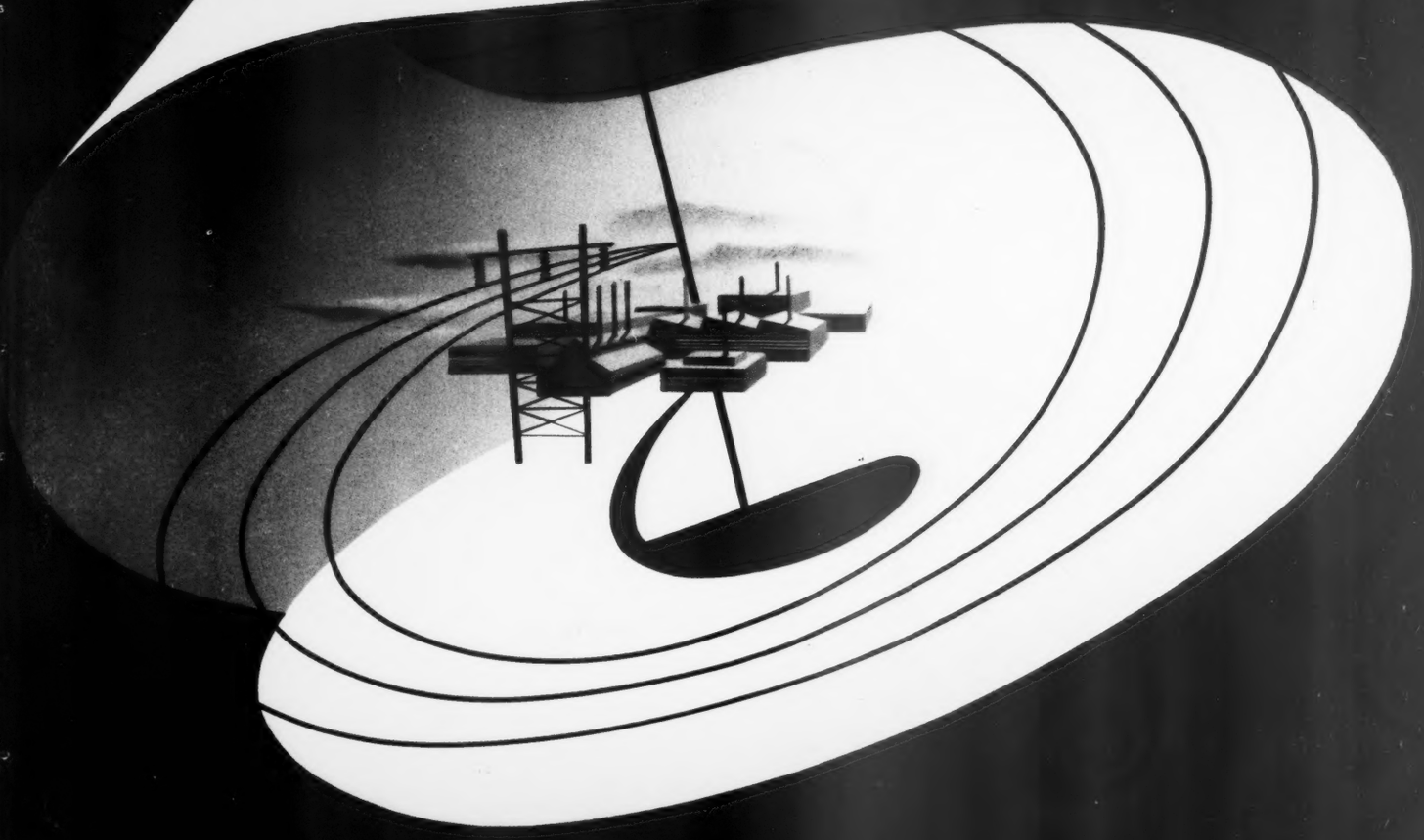
WESTINGHOUSE

Engineer



Science and Engineering—1948 STYLE

A glance at the face of science and engineering discloses many familiar features, features characteristic of the technology before the war interruption. There is the usual quota of spectacular things: a new method of providing visible indication of airport runways even in the thickest fog; a device, using x-rays, to measure thickness of sheet steel racing through the reduction rolls without the steel being touched; high-speed x-ray motion pictures are taken through solid walls at 100 frames per second. But, most engineering, as always, is concerned with less spectacular things. Here are the evolutionary simplifications, such as turbine-generator excitation systems without the usual contact-making regulator and even without the pilot exciter, and the simple single-phase motor improved so that it replaces the more complicated repulsion-start type. Also the other usual aspect of apparatus evolution—expansion of abilities—is in evidence. For example, the power-transformer relay that anticipates an overtemperature condition and turns on coolers, giving it three functions instead of just the usual two warnings.

As before, limits to size are being elevated: transformers have passed 100 000 kva; 65 000 hp motors—more than half again larger than any before—are being built. Engineers have pushed turbine temperatures up to a new notch—to 1050 degrees F from 1000 degrees F, a feat more difficult than the mere 50-degree increase suggests.

As always the most urgent objective of engineering is to reduce costs and with steeply rising charges this factor in engineering has been greatly intensified. New controls and new drives make it possible for sheet steel—shortage of which has cramped so many postwar production plans—to be made at the breath-taking speed of a mile a minute. Navigational radar, modified from military types, enables ship operators to cut down time lost in fogs.

The recent months have displayed, in addition to familiar aspects of engineering, some sobering, unglamorizing factors. It is now recognized that radar cannot be quickly converted to solve all the safety problems of aviation. Materials short in quantity and too often in quality will be the engineers' lot for some time to come.

Atomic energy is being viewed in sharper, more realistic outlines. It has become apparent that those who predicted early commercial use of atomic energy were much too optimistic. The reasons for this cannot by any means all be laid to the door of the international situation. The engineering problems of useful atomic energy piles were for the most part anticipated by those associated with the work, but the answers are not coming as easily or as quickly as was hoped. The early research with atomic energy has made engineers realize how truly appalling is our lack of knowledge about materials. Atomic energy is a force many magnitudes greater than we had known before, but with it come problems of like size.

A look around at an assemblage of engineering and scientific accomplishments in any one year gives a technical man a justifiable feeling of pride—but not of complacency. He is too aware of the work yet undone, of the great gaps in engineering knowledge. Fortunately for the profession there is a growing national awareness of the need for research. The President's proposal of a national committee to sponsor fundamental research costing billions is an indication. Companies like Westinghouse plan to spend more for research than at any time in history.

A newly built mechanical calculating laboratory gives a broad hint of what lies ahead. It is a six-fold expansion of the electro-mechanical analog laboratory built at East Pittsburgh just three years ago. It is an impressive array of panelboards, switches, instruments, commutators, and computer tables filling a large room. One cannot resist the feeling that it is a mathematical Paul Bunyan, which, in a twinkling, can chop its way through the forests of problems and soon be looking hungrily for more. However, the director of the new problem laboratory has a fat folder of papers, listing pages of problems classified by kind that await their turn with the mechanical mathematician. It is by no means an exhaustive list, yet this calculator will be busy for years even if its operators never hear of another problem.

The answers to these problems are not just to satisfy the academic curiosity of engineers. They are to enable machines to be built better tailored to the jobs to be done, to permit materials to be used exactly where they are needed, to anticipate the troubles new devices will encounter, to enable equipment to be made to do things not done before. Such answers will save millions of dollars in field testing and untold years of time in development.

Engineering technology is yet young; there is an awareness of the magnitude of the unfinished business, we have the tools and the men for their accomplishment, and, above all, men of science and engineering have the will—indeed the zest—for the task.

WESTINGHOUSE
Engineer

VOLUME EIGHT JANUARY, 1948 NUMBER ONE

On the Side

The Cover: Locked in step with research and engineering developments is an endless procession of new, better machines that serve better the needs of public utilities, industries, and homes.

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Indicative of man's desire always to set new records, to press beyond existing ceilings is the announcement that this year will see the erection of the tallest man-made structure. The aerial tower for radio station KRNT, Des Moines, Iowa, will be 1530 feet high. This makes it 280 feet taller than the present highest structure, the Empire State Building and nearly three times the elevation of Washington Monument. It will permit good coverage in a 120-mile radius of the 50-kw Westinghouse FM transmitter and later serve also television and facsimile transmitters. Pairs of 500-watt flashing beacons at five levels will warn aircraft of its presence. No special lightning protection will be required. The tower itself is a gigantic lightning rod for the many strokes it will intercept yearly. Rest stations for maintenance men climbing the tower are spaced at approximately 100-foot intervals.

• • •

Facilities for international flying are growing steadily. Complete equipment for ten Turkish airports has been purchased of Westinghouse. Three of these airports are international or primary airports and seven are smaller or feeder airports. The equipment for the airports will include, in addition to high-intensity runway lighting, instrument-landing systems, radio navigational aids, and radio teletype point-to-point communications—even the terminal buildings, hangars, and airport auxiliaries.

This modernization of Turkish airports is but typical of the rapid development of aviation facilities throughout the world.

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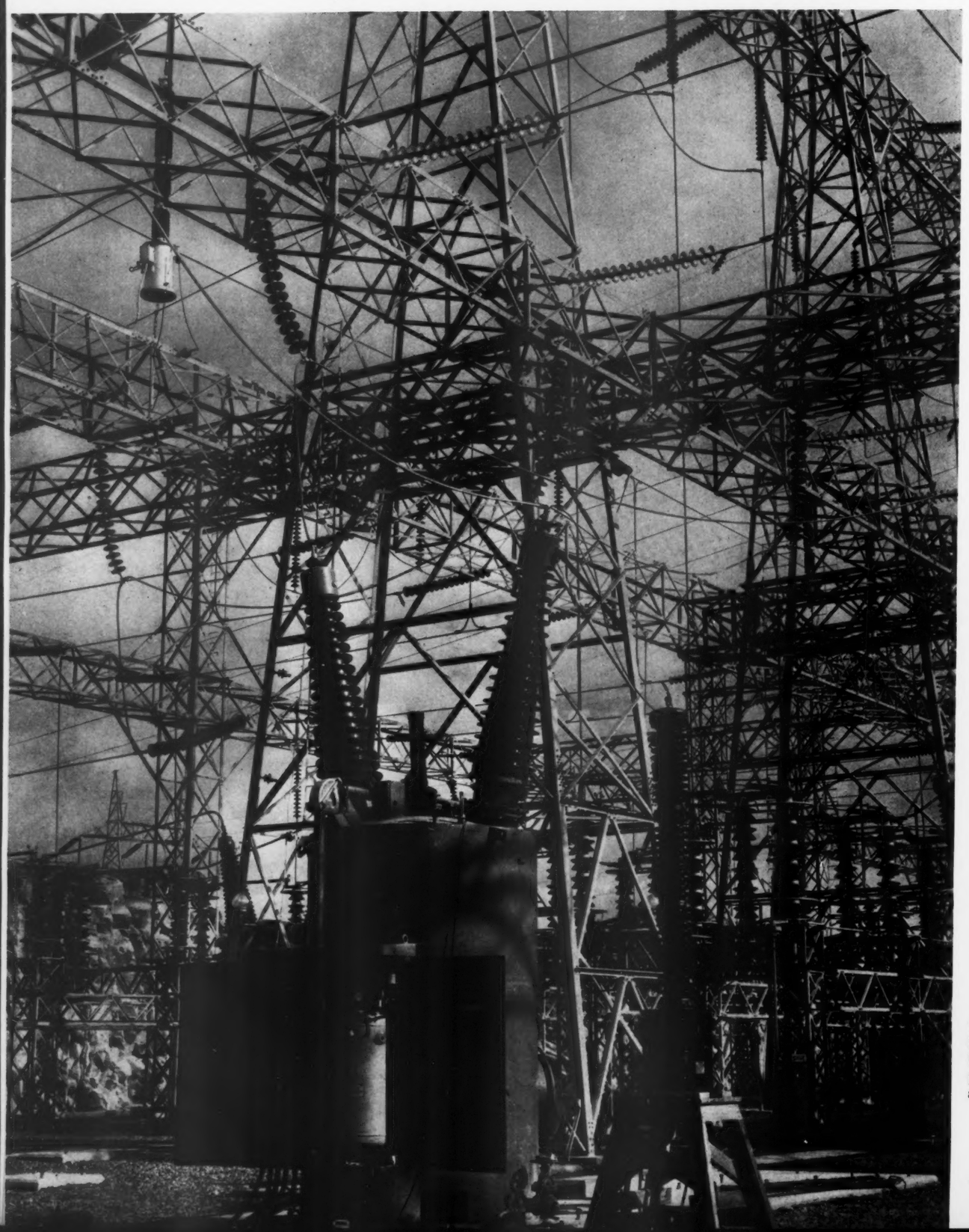
Power —

Its Generation, Distribution and Control



The multi-grid De-ion circuit breaker as it was prepared for test at Grand Coulee.

Circuit Breaker Interrupts 7½ Million Kva

GENERATING systems can give it; can circuit breakers take it? Answer was given to that question last spring in dramatic fashion when a circuit breaker of the dead-tank type easily interrupted short circuits of more than twice the kva rating of any breaker now in service. This was all the energy that the six Grand Coulee generators and six incoming lines solidly tied together could muster.

With power systems growing larger the amount of energy that may be dumped into a single short circuit is rising steeply. For example when all 18 of the 108 000-kva generators are installed at Grand Coulee the faults on the 230-kv bus may reach 10 000 000 kva whereas the largest circuit breakers now installed are rated only 3 500 000 kva.

To assist in the development of higher capacity breakers, the Grand Coulee power plant was turned into a gigantic high-power laboratory. The entire Bonneville system and Northwest power pool were tied together through six 230-kv transmission lines into the Coulee switchyard and paralleled with all six of the existing 108 000-kva generator and transformer units installed in the power house. Westinghouse provided a test, single-pole circuit breaker with the latest design of multi-flow De-ion-grid interrupters. This breaker, furthermore, was contained in a tank only 84 inches in diameter, instead of the 108-inch tank standard four years ago for 3 500 000-kva ratings. The oil volume has been reduced by almost one half. The breaker was operated by a compressed-air mechanism suitable for high-speed reclosing service.

In order to squeeze every bit of short-circuit energy into the test, the breaker was pre-tripped so that a fault current was established just as the contacts began to separate. Climaxing a group of 15 tests were two tremendous short circuits with the total rms currents reaching 17 800 and 18 200 amperes respectively, corresponding to a three-phase fault of 7 500 000 kva at the bus voltage of 238 kv. All interruptions took place within the rated time of three cycles; one test showed only a single asymmetrical current loop and cleared within 1.85 cycles after the tripping impulse.

In the second series of tests using high-speed reclosing with both 60-cycle and 18-cycle intervals, double interruptions were handled successfully up to full power. The maximum current was 14 550 amperes (inasmuch as pre-tripping could not be arranged) equivalent to a three-phase fault of 6 000 000 kva.

Before making these record-breaking tests at Grand Coulee, the interrupters had been thoroughly tested in the high-power laboratory at East Pittsburgh up to currents representing 9 000 000 kva by using 66 kv, or half the normal line-to-ground voltage across a single grid. This test, far in excess of the three-phase rating of the laboratory, was made using special synchronous timer controls to obtain a fully offset wave on the first half cycle and by applying the short circuit to only one grid of one pole or one sixth of the total breaker. As a result of the confirmation provided by the Grand Coulee field tests, circuit-breaker engineers are willing to undertake the construction of a three-cycle, 230-kv breaker rated 10 000 000 kva on 20-cycle reclosing duty.

This means almost tripling the interrupting capacity of circuit breakers over any now in service. Also it is planned to increase the rating of some 3½ million-kva breakers installed only five years ago to 10 million kva by replacement of grids, strengthening the pole-unit details, and providing a pneumatic operating mechanism suitable for 20-cycle reclosing. The existing 108-inch tanks are more than large enough for the modern, more effective interrupters.

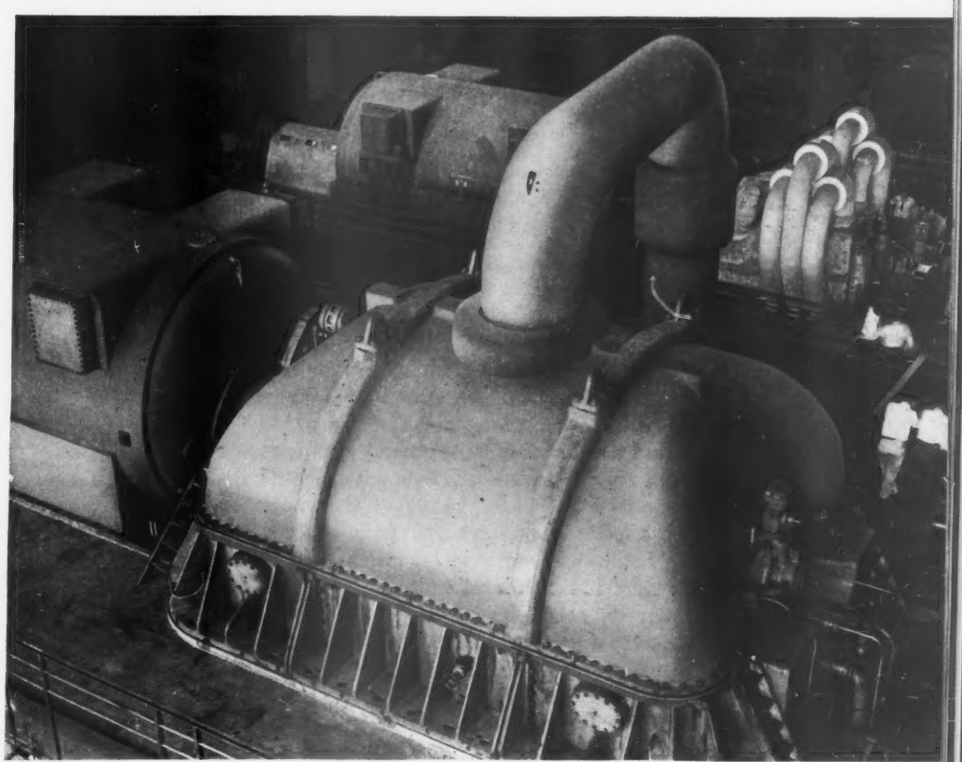
Turbine Generators Are in the News Again

TURBINE-GENERATOR developments, after a long war-imposed recess, are back again. And back with a bang. In terms of number and size of units there has never been anything like it. Between war's end and the fall of 1947 Westinghouse undertook the construction of about 80 large generating units totaling 3½ million kw or nearly 7 percent of the total installed central-station steam capacity in the United States.

One of the most conspicuous phases of this unprecedented burst of activity is the large proportion that are standardized units. Forty-six standard units, aggregating about two million kw, have been built or are under construction by Westinghouse (as of October 1). Omitting superposition units and those turbines within the capacity range of standardization not used in central stations, about two out of every three new turbine generators are of the standardized variety. Among these forty-six units, the distribution by rating is: eighteen 60 000-kw, seven 40 000-kw, eighteen 30 000-kw, and the remaining three are smaller sizes. Of these three larger sizes, six are designed for 1250 pounds gauge, 950 degrees steam and thirty-seven for 850 pounds gauge, 900 degrees.

Another important and difficult increment has been taken

The new turbine generator, in the Southwark station of the Philadelphia Electric Co., consists of a 65 000-kw, 3600-rpm, and a tandem-compound 85 000, 1800-rpm unit.



in steam temperature. The top now rests at 1050 degrees. The first to enter service at this new peak will be the 100 000-kw machine for the Sewaren Station of the Public Service Electric and Gas Company of New Jersey, on the line this year. The largest unit for this top temperature is a three-casing, 150 000-kw cross-compound machine. It will be installed in the Ridgeland Station of the Commonwealth Edison Company of Chicago.

For machines operating with temperatures above 950 degrees, the materials are being worked to their allowed physical limit. As a result, careful consideration must be given to the shape of the structure to hold to the minimum the secondary stresses resulting from thermal distortion of the casing. The designer's approach to machines of this class is to reduce the structure to the simplest physical form. Component parts are made of forgings instead of castings to obtain maximum utility of materials. Throttle valves, steam chests, nozzle chambers, and other parts subjected to the high temperatures are made of forgings or simple castings.

Other machines are notable for their size. Among these is the first 150 000-kw unit undergoing erection in the Southwark Station of the Philadelphia Electric Company. It will be followed by a duplicate for service in early 1948. Several 80 000-kw (100 000 kw maximum), 3600-rpm condensing units, such as one for the Buffalo Niagara Electric Company, mark the extension of the 3600-rpm, single-shaft turbine into the larger kilowatt sizes for steam conditions in the region of 1250 pounds gauge, 950 degrees or 850 pounds gauge, 900 degrees. Of interest is the 30 000-kw, non-condensing, automatic, double-bleeder turbine to be installed by the Dow Chemical Company at Midland, Michigan, in 1949; it will be the largest unit of this type.

A 65 000-kw turbine with steam conditions of 1450 pounds gauge, 1000 degrees employs reheating to 1000 degrees. It marks the return of the reheat principle to central-station turbines after a comparatively long absence.

The 23-inch long exhaust blade, (1380 feet per second tip velocity) the development of which was mentioned in a previous review, has been tested. It is used on all machines (80 000 kw and over) whose steam flow requires it.

The larger stationary, low-pressure blades are now made hollow. Considering the size of these blades and that they are made of relatively expensive stainless steel, it is a worthwhile economy of material and weight to fabricate the blade, leaving it hollow, instead of casting it solid.

Spreader-Type Firing Makes a Comeback

THERE is no record that the first primitive man to toss logs on top a fire got a patent for the idea. However, in so doing he established one of two basic methods of feeding fuel —the spreader system. The other is to push it in from below, i.e., the underfeed principle. Piling fuel on top a fire is obviously simpler and much easier. But, generally, in furnaces burning bituminous coal the spreader method is charged with making smoke and with serious loss of fuel up the stack. For these reasons underfeed stokers have been popular for a half century. Meanwhile, the spreader principle, with its appealing possibilities, has stood in the "wings" waiting for its day. Several unrelated developments have come along over recent years, which, put together, free the spreader type of stoker from its handicaps.

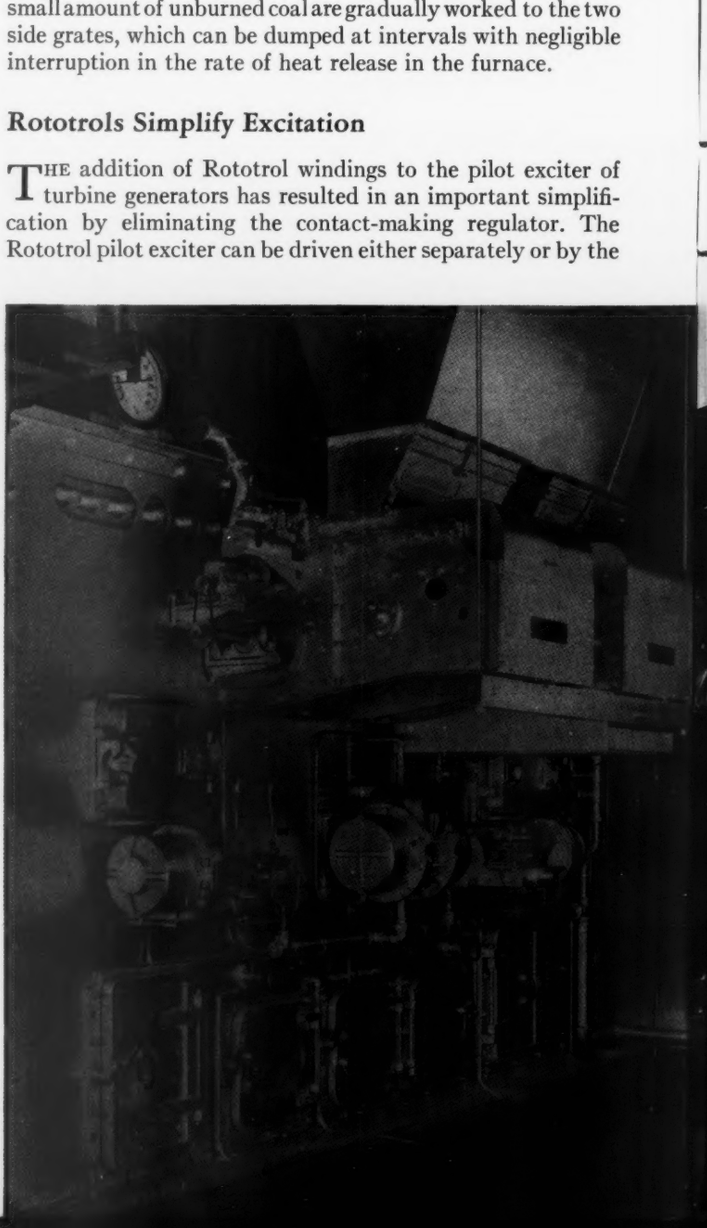
New and greatly improved controls insure the rapid and accurate maintenance of the all-important ratio of air to fuel, under all conditions of load and rate of fuel injection. This guarantees adequate air for complete combustion —hence smoke prevention—without waste caused by heating unnecessarily large quantities of air. Then, excellent mechanical filters are now available that trap unburned solid particles of fuel, which would be blown up the stack, and return them to the furnace.

The new stoker makes use of these developments. Called the Centrafire, it incorporates the Link-Grate feature of the earlier underfeed stoker. It is in two sections, a main or center section and two side or wing areas. The coal is thrown over the central grate by a "manure-spreader" device. Here it is burned in a thin bed with air purposely inadequate to maintain relatively low combustion-gas velocity. Thus there is much less tendency for the fine particles of fuel, as they rain down, being swept up the stack by the rush of hot gases. Then, to complete the combustion of the hot gases before they too escape, excess air is introduced at the side zones in such a way as to meet these partially combusted gases with great turbulence in the region above the entering fuel. The result is complete combustion with low particle carryover. This, with good mechanical dust traps, insures a clear stack.

Another important improvement is the means of removing ash. The main grate is a Link-Grate sloping slightly downward from the center to the two sides. The grate moves at a very slow rate and with small motion so that the ash and a small amount of unburned coal are gradually worked to the two side grates, which can be dumped at intervals with negligible interruption in the rate of heat release in the furnace.

Rototrols Simplify Excitation

THE addition of Rototrol windings to the pilot exciter of turbine generators has resulted in an important simplification by eliminating the contact-making regulator. The Rototrol pilot exciter can be driven either separately or by the



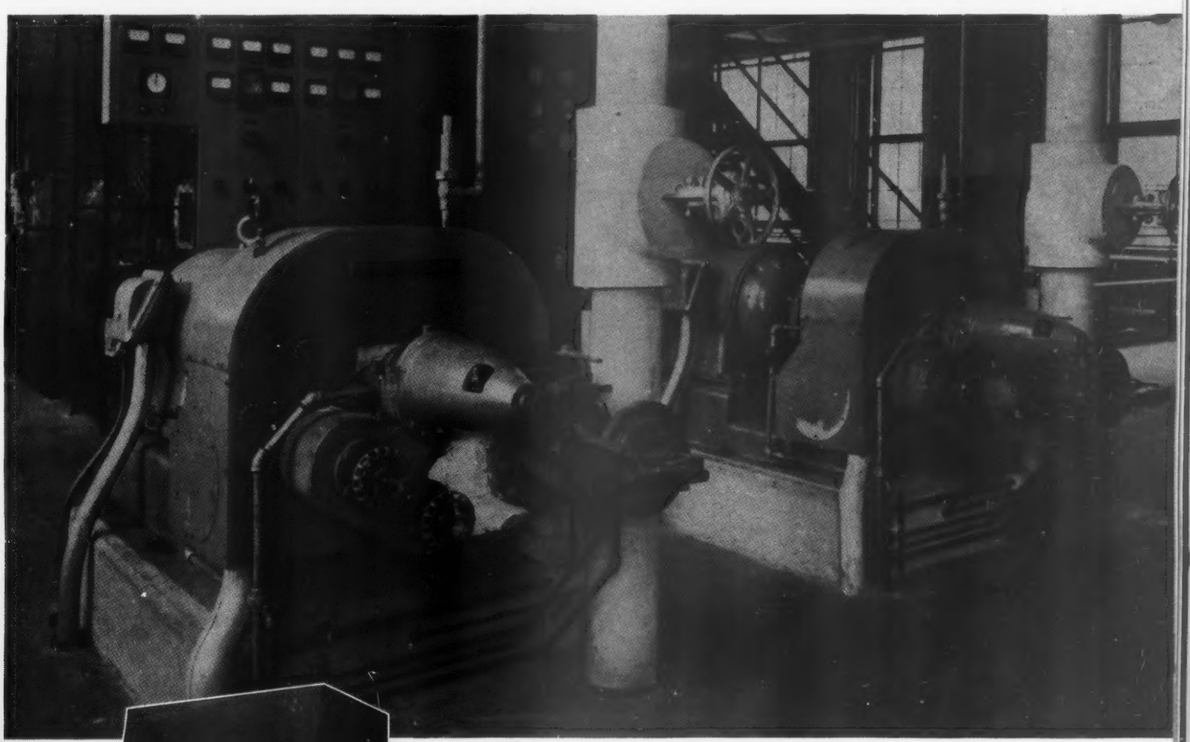
machine it serves. Fully a dozen large generators now being built will employ this form of Rototrol excitation.

A further step in simplification is to eliminate the pilot exciter altogether. The development of the two-stage Rototrol will make this a reality. By equipping the main exciter with a double set of Rototrol windings it can serve as its own pilot. Thus, excitation is reduced to a single, direct-connected machine of normal main-exciter size with an almost perfect service record for many years. Furthermore no additional current-collection problems are introduced to the commutator of the Rototrol exciter; rather, they are reduced by the elimination of one commutator. A two-stage Rototrol exciter of 200-kw capacity is being built for a 60 000-kw generator to be installed in 1948 in the Redondo Beach plant of the Southern California Edison Company.

With the size of high-speed generators mounting steadily the practical limit of conventional 3600-rpm, 250-volt exciters has about been reached. Direct-connected exciters are built in capacities up to 300 kw at 250 volts. However, the largest 3600-rpm generator contemplated (150 000 kw) will require in the neighborhood of 400-kw excitation. To obtain the necessary exciters of larger rating a higher voltage is preferable to simplify exciter current collection and reduce the size of generator collector rings.

The 375-volt excitation system, which two generators now being built by Westinghouse will employ, has one particular advantage. When used in a station with 250-volt exciters and a 250-volt standby unit, a new 125-volt standby exciter can be provided whose capacity need be only one third that of the shaft-driven unit. The new 125-volt exciter, connected in series with the existing 250-volt standby unit or bus, provides the desired 375-volt excitation.

The electronic exciter discussed a year ago has continued to perform satisfactorily except for minor, readily corrected mechanical difficulties. Active study of it continues. While it has many attractive features its cost in the foreseeable future will be high compared to shaft-driven exciters whose popularity continues. The direct shaft-driven exciter has continued to match the growing reliability of boilers and auxiliaries. Developments in recent years, such as the elimination of all bare copper except the current-collection parts and the new "plug-in" brush mechanism that allows brushes to be changed with the machine running and without tools, has given the rotating exciter an enviable record of reliability and low maintenance.

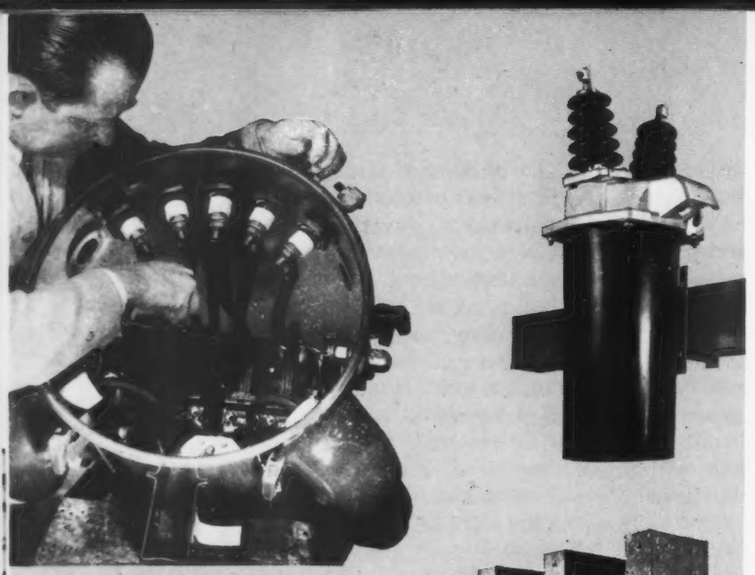


Students can study at first-hand modern steam power plants using apparatus designed for that purpose, such as this one at M.I.T. Each of two single-stage turbines drives a two-pole, 25-kw alternator. The plant can illustrate condensing, non-condensing, automatic and non-automatic extraction, reheating, etc., and various types of electric operation.

At left is a stoker and boiler rated at 39 000 pounds of steam per hour at a plant of American Home Foods, Inc. Below, the slot-discharge detector is checking the windings of a high-voltage a-c generator on a test floor.

No Bottlenecks to Power-Transformer Ratings

POWER-TRANSFORMER engineers are breathing easier. Whenever the top rating of an apparatus is pushed to a new high the creators must check tried and tested designs and construction to determine if they continue to hold good. Last year the kva and voltage ratings of power transformers were lifted considerably. Several new marks were set. The transformers for the experimental high-voltage lines of the American Gas and



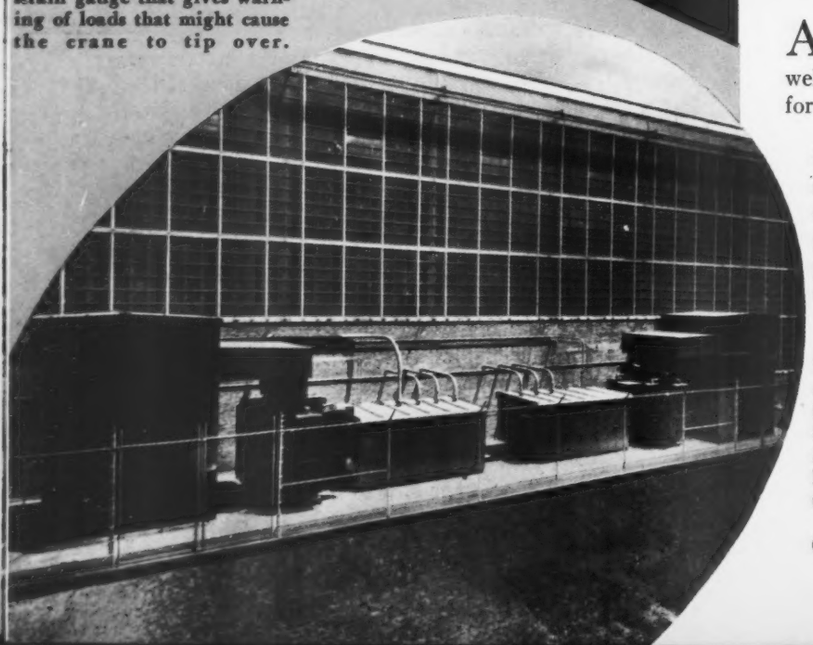
In the transformer above are the new breakers (BR) that permit raising capacity limits of self-protected distribution transformers.

Upper right is a 15-kv, 50-ampere recloser capable of interrupting 1200 amperes for rural service.

The breaker (right) was developed to meet the need of frequent opening of normal arc-furnace currents.

An 11-kva air-cooled transformer for aircraft service (above) weighs but 16 pounds.

The small box (right) attached to the boom of a crane contains a magnetic strain gauge that gives warning of loads that might cause the crane to tip over.



Electric Service Corporation delivered 500 kv; 287 kv had been the previous top operating limit. The 105 000-kva, 69-kv units for Philadelphia Electric Company, the 83 333-kva, 220-kv units for Bonneville Power Administration, and the 50 000-kva, 132-kv units for Consolidated Edison Company all set new records for size in their respective classes.

None of the new ratings required any deviation from well-established practice. Extrapolation of existing design principles and construction methods proved entirely sound.

All Westinghouse large-capacity, high-voltage transformers are shell-form, form-fit, and use Hipersil cores. In fact these three factors working together make it possible to continue the skyward climb of transformer ratings without raising weights and dimensions beyond shipping and handling limits. The Bonneville transformers, for example, have ratings of 50 000, 66 667, or 83 333 kva, depending on whether operated self-cooled, forced-air cooled, or forced-oil and forced-air cooled. They are the largest single-phase units ever built, yet they weigh only 306 000 pounds and were shipped lying down, the largest piece being 180 000 pounds. These low weights are most important from an erection standpoint.

The advantages of shell-form construction become increasingly conspicuous with the large multi-winding high-voltage transformers now so common. With it the tank wall can be placed physically close to the core and coils without introducing electrical insulation problems. The form-fit tank greatly reduces the dimensions and cuts the tonnage of oil necessary for insulation. Cores of grain-oriented steel (Hipersil) having one third better permeability in direction of grain, mean less iron in the magnetic circuit; hence, shorter coils, again with a saving in weight.

Several other factors of importance but not as fundamental bear on the new high-voltage, high-capacity transformers. Greater subdivision of conductors (sometimes three) and more conductors on edge result in more turns wound in a given space and thus reduce overall dimensions.

Wheels are an important component of large transformers. An arrangement that allows the wheels to be turned 90 degrees permits the transformer to be moved in right-angle directions. Thus only one set of removable wheels without the transfer truck and more complicated track construction otherwise required can serve several transformers. Furthermore they can be stored indoors out of the weather, a matter of importance to the bearings, which are infrequently used.

Improved Transformer Overload Protection

A RELAY with a memory, a relay that considers the temperature of the atmosphere, the previous load condition, as well as the existing load, before acting for its power transformer—that's the new TRO.

Redesigned with new features, this relay has three jobs instead of the two of its predecessor (the TRC). With appropriate equipment it will, in order: (1) turn on blowers or coolers to increase the capacity of the transformer, (2) give visual or audible indication of impending over-temperature, and, if this notice goes unheeded, (3) trip breakers to remove the load from the line.

This is the first installation in the United States of indoor compressed-air breakers in outdoor housings. Similar units have been developed for service voltages up to 34.5 kv and interrupting capacities up to 2½ million kva. This construction is compact and eliminates overhead structures with exposed live parts. They are adaptable to residential areas because of the small space required, clean appearance, and simplicity.

Other improvements have been made. The new relay is now arranged for mounting on the outside of the transformer tank where it is accessible for inspection and calibration check. The principle of operation on copper temperature, in which the TRC pioneered, remains as before, though considerably improved methods are used. A current proportional to transformer load current is passed through a special heater coil possessing thermal characteristics matching those of the main transformer. The spiral bimetal of the relay is enclosed by the heater coil. Both heater coil and bimetal are mounted on the tank wall in the oil-tight well, which extends into the hot oil. Thus the action of the relay is based on integration of copper, oil, and air temperatures.

Movement of the coiled bimetal actuates three separate microswitches. The bimetal exerts a much greater torque than is needed to close the switches. This enables the relay to hold calibration well.

Small Transformers Profit from War Experience

FEW types of electrical equipment have benefited so much from war experiences as small, special-purpose transformers. In the first place many applications for these baby transformers were either created or accelerated into reality by war developments. Such, for example, are units for 400-cycle aircraft power systems, military and commercial radar, industrial uses of ultra-high frequencies, and electronic controls. Secondly, the designer has at his command new materials and methods by which to produce the necessary transformers. Among these are Hipersil, the grain-oriented steel (using ribbons as thin as one mil), methods of making wound-cores so small they could slip through a lady's finger ring, moistureproof protective coverings, and better insulations.

Use of alternating current on aircraft has led to the creation of a family of 400-cycle, single-phase autotransformers. They use cores of Hipersil 0.005-inch thick, glass, silicone, and other high-temperature insulations to allow operation at 225 degrees C, and are air cooled with a special ventilated-coil construction for maximum heat dissipation. By these devices the transformers achieve sizes surprising to power men accustomed to 60-cycle transformers where weight reduction is not in supreme command. The baby of the family, the 0.1-kva, weighs but 14 ounces, while the largest, 5-kva, only 7 pounds. The 3-kva auto fits into the equivalent of a 4-inch cube and weighs but $5\frac{1}{8}$ pounds, about 1/25 the weight of a 60-cycle, oil-cooled distribution transformer of comparable rating.

A special 11-kva, 3-phase, 2-winding transformer has been provided for aircraft window-heating systems (see p. 8). It uses class-H (high-temperature) insulation, is air cooled, and weighs only 16 pounds or about 1/16 as much as a corresponding 60-cycle distribution transformer.

Commercial radar, television, and FM radio will obviously inherit directly the virtually identical high-frequency transformers developed for military radar service. Also many modifications are carrying over to better, smaller transformers for electronic controls at lower frequencies. In fact small, lightweight transformers, hermetically sealed in aluminum cans with plug-in terminals, have been a factor in advancing industrial electronics. Fourteen such units are visible on the front of the new paper-mill regulator shown on p. 22.

New Elevator Control Handles Peaks Smoothly

WAITING on the um-teenth floor for an elevator during the five o'clock rush, and wanting to catch the 5:15 is a common experience hard on tempers. Elevator dispatchers do their best, but it is humanly impossible to cope perfectly with the flood of stop calls, changing second by second in distribution up and down the building. It is more a job for a machine. Such a machine is now at hand. It is called the Selectomatic.

The new system of supervisory elevator control adjusts itself

Test is being made of electrically heated airplane-window controls.

The scheme of using banked-secondary CSPB transformers to increase distribution-system capacity has been adopted almost nationwide in less than two years. Already many hundreds of units have been or are being installed by about 135 power companies in the United States.

This electronic telemeter uses a light beam passing through holes in two rotating discs to give a dispatcher the measure and direction of power flow.

automatically to changing traffic conditions to provide a minimum waiting time and more uniform service to all floors. With its aid, the elevator starter, simply by pressing a button, selects the supervision required by the load. From that point on, Selectomatic takes over and automatically directs each car. No longer need the starter try to coordinate calls with cars.

Peak loads are customarily handled by a load center established at the center of population of the building. One half the cars serve the top section and the other half the bottom section, thus reducing round-trip time and the number of stops. If service demand in the two zones remained constant in ratio, this system would be adequate. However, what often happens is a series of lulls in one zone accompanied by sudden peaks in the other; this cannot be coped with by a simple load division. Such situations, however, are precisely the reason for Selectomatic, which automatically "lends" cars from one zone to the other during down-peaks, and during up-peaks reverses cars when they have answered the highest call in their zone. To handle off-peak conditions, cars are dispatched by timed signals in order of their arrival at both the top and lobby floors and are automatically put back on schedule when it is interrupted by momentary lulls or peaks. Other refinements help provide excellent service during all possible situations.

Up-peak traffic occurs with the morning rush. The attendant, simply by pressing an "Up-peak" pushbutton, prepares the elevator bank for the rush before it starts. Similarly, there is a down-peak at the noon hour and for a half-hour period around five o'clock. This is handled with the maximum efficiency by Selectomatic control when the attendant presses a "Down-peak" button. When both buttons are released the bank operates with its off-peak performance, which has been found to be the most satisfactory way of handling traffic during mid-morning and mid-afternoon hours.

Selectomatic control is applied only to banks of elevators of four or more cars where automatic stopping is provided and where starting is under the control of a car attendant.

Smaller Breaker Permits Bigger Transformers

THE fashioning of a key for a lock may be a long, slow, seemingly unproductive task. But, upon successful completion, it may be the means of opening doors to large new vistas. It has been that way with protective breakers for the larger sizes of distribution transformers. Engineers have worked for years to develop a breaker of high interrupting capacity, but small enough for the space available.

Such a breaker, now that it is available, raises the rating ceiling for several distribution transformers. The transformers on which it will be used can experience, theoretically, maximum short circuits of 8500 amperes. The new breaker, known as type BR, has been tested in the high-power laboratory to currents well above this figure, with complete success in every case, yet the complete single-phase, two-pole breaker is only six inches square by eight high.

Self-protected transformers are now possible in 37½- and 50-kva ratings using but a single breaker instead of the two previously required. Also, transformers for banked-secondary operation can be built in sizes up to 37½ kva, more than doubling the previous limit of 15 kva.

The construction of the breaker in single-pole units, which may be built up as two-pole or three-pole combinations, permits flexibility of application to either single-phase or three-phase transformers. The three-pole combination makes it possible to build three-phase CSP units up to 75 kva—an entirely new addition to the field of completely self-protected transformers.

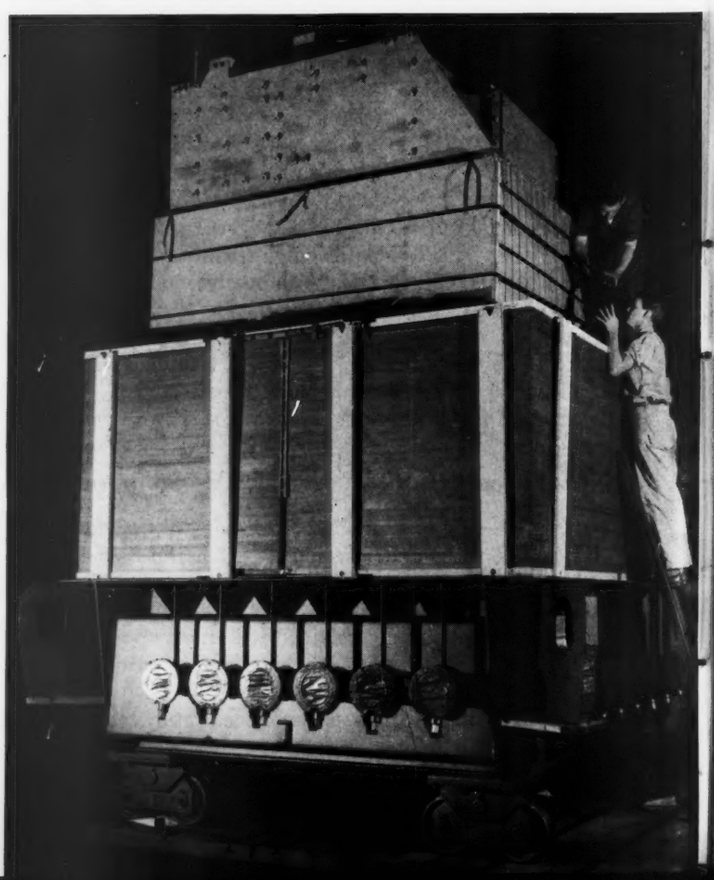
Aircraft Window Ice Removal

ICE or frost on an automobile windshield is a nuisance. On the windshield of an airplane it is a hazard that cannot be tolerated. The problem is a major one. An airplane window may, under the conditions of rapidly varying temperatures and altitude, ice over in a few seconds. Many schemes have been tried, such as passing hot air between layers of glass comprising the window, passing current through imbedded resistance wires, or infrared heating. None has been an unqualified success.

A novel one is being tried extensively with early indications of being a satisfactory answer. It consists of passing current through a transparent conducting film on the window "sandwich." This is now being applied on a commercial scale to several large military and public-transport planes.

The pilots' windows normally consist of a shock-resisting layer of vinyl from 1/16 to 1/4 inch thick between two layers of tempered glass. The electrical conductor, microscopically thin, is placed between the layers of laminated glass. Strips of silver along two opposite edges comprise the busbars. Temperature-sensitive elements of metallic oxide or of special resistance wire are embedded at appropriate spots and are connected in a bridge circuit to control the voltage applied to the busbars. A potential of about 400 volts is applied across the busbars on an on-and-off basis, the time ratio being determined by the temperature-sensitive elements. It is essential

The 50 000-kva (self-cooled) transformer for the Bonneville power system is about to receive its form-fit tank. It was shipped as a unit.



that the window temperature be held between fairly close limits as the impact resistance—a protective measure against birds, for example—falls off sharply if the temperature of the shatter-proof layer is not between 70 and 130 degrees F.

Because the high voltage required is considerably above practical aircraft generator voltages, alternating current, which permits use of transformers, is used. The power plants for one class of airplane being built consist of a pair of 11-kva, three-phase, engine-driven alternators. One generator is normally ample to supply all the power required for window heating, the second ordinarily used for cooking, coffee warming, etc. In emergencies the second generator can replace or assist the first generator as the situation requires.

For Precise, Repeated Stops

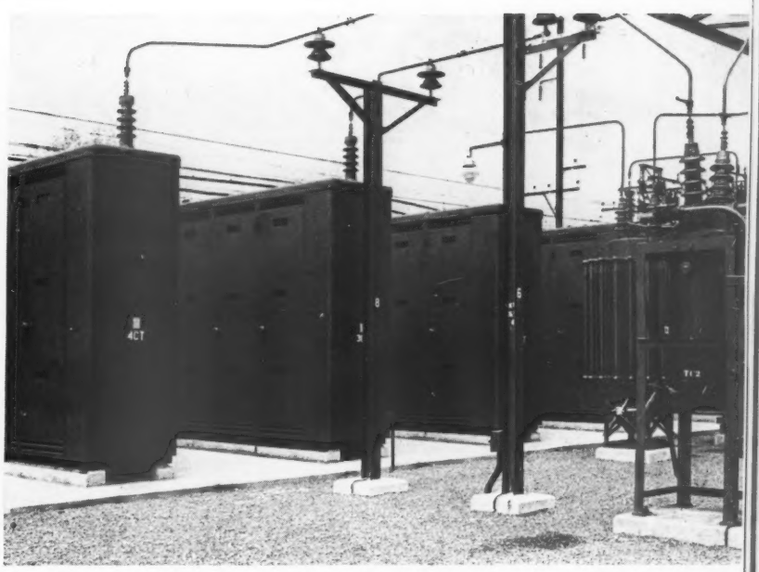
LIFT bridges, car dumpers, gates of dams and locks, and various types of hoists must operate repeatedly and yet always stop extremely close to a preselected spot. For more precise operation of such equipment than has heretofore been possible a new limit switch has been devised. It is a cam-action switch, with the extremely large cam diameter of 12 inches, that can be set with vernier screws to operate repeatedly within 1/4000 of its total travel. Thus a gate with a 10-foot travel is made to stop within three hundredths of an inch of a chosen point at each operation. The cams are also adjustable so that each element can be reset after only 0.7 percent of the total rotation. This makes it possible after, say, the improper spotting of a crane load, to reverse the hoist motor, raise the load only the slight distance needed to reset the switch element (just 0.7 percent of the total travel), and repeat the incorrect operation with a minimum of lost time. The switch is built with either six, eight, or twelve elements, each containing both normally open and normally closed snap-action contacts. Shaft bearings are permanently lubricated and sealed. A tight gasketed cover limits entries of water and dust and an internal heater prevents damage from condensation of moisture. No internal gearing is employed, the switch being driven by an external gear connected to the mechanism it controls.

Rototrol Moves to New Fields

THE rotating regulator, called the Rototrol, continues to display its versatility by its application to new kinds of tasks. Several more were registered last year. One of these is its use on turbine-electric sea-going hopper dredges to maintain constant horsepower automatically regardless of external operating conditions after the full-speed point on the controller is reached. With it such extreme maneuvers as dredging under full propulsion power or a "crash-stop" from running at ten percent overload cannot only be performed easily but also without excessive power surges. The rapidity of reversal and lack of surges, even when the control is thrown from full ahead to full astern, is most impressive.

On paper machines and rolling mills Rototrol affords automatic control and regulation over a wide range of operating speeds and synchronization between different sections. On lift bridges, it keeps the ends in line to avoid tilting, which sets up undue stresses and strains, and does it without the aid of Synchrotie equipment, a previous "must"; also it can be used with a gas-engine-driven d-c generator set, if necessary. Applied to a variable-voltage planer, Rototrol permits as many as 120 reversals per minute with limited peak currents.

The few Rototrol applications that require extremely high amplification with low power input can be handled easily by providing two stages of amplification. This can be accomplished either by using two separate machines, one a conventional exciter and the other a Rototrol, or by a special two-stage Rototrol. This unit obtains both stages of amplification with a single armature and differs from the standard machine only in the addition of a number of second-stage field coils and compensating coils. A two-stage Rototrol can be controlled over its entire range with amplification up to a million to one.



One of the largest installations of capacitors is a bank of 10 000-kva, 25-cycle, single-phase units to increase the power factor and line capacity for New York, New Haven, and Hartford Railroad.

Transformer Oil Reconditioner

NOW transformer oil may be given an opportunity to recondition itself continuously. An oil conditioner, consisting in the main of a cylinder of activated material, is mounted on the transformer tank through which the oil circulates by natural thermosiphon action. Experiments conducted over several years have demonstrated the efficiency of the system as a means of removing moisture and other agents that decrease the dielectric strength of the oil and increase its power factor. This has led to a practical structure—a replaceable cylinder 12 inches in diameter and 50 inches long—that can be supplied either with new transformers or added to those already in service.

Single Sideband Carrier Now in Action

THE form of carrier current known as single sideband now possesses actual service experience. Ten terminals have been installed in three areas, the Pacific Northwest, Arkansas, and Texas. Practical operation demonstrates the economy of band width and low noise level, promised by the theory described here two years ago. In this system the signals—voice or control—are carried by the power-transmission line between two distant stations or terminals by a sideband of the basic carrier-wave frequencies, the second set of sideband frequencies being suppressed. (In carrier-current work, three frequencies are generated: the carrier frequency itself, the carrier plus signal sideband frequency, and the carrier minus the signal frequency.)

Drives and Power Conversion

3200-Volt
Ignitron

Pumped Ignitrons Go to Higher Voltage

THE maximum voltage rating of large-capacity, continuously pumped ignitrons has suddenly been multiplied about fourfold, from about 750 to over 3000 volts. Early in 1947 a 1500-volt, 1500-kw ignitron was installed to serve an electrified railroad. More recently two 3000-kw ignitrons were installed to supply power at 3200 volts to locomotives of a copper mine in the West. Several others of similar voltage but for 2000 kw each have been built to serve a railroad electrification. Some units will serve not only as rectifiers but also as inverters to pump regenerative-braking power back into the lines. When used as inverters, the rating is reduced by approximately one third.

The creation of high-power, pumped ignitrons for this high voltage entailed no basic change in construction. Many detailed ones were necessary however. To provide positive seals at the temperatures at which the mercury is worked, a new type of seal was devised, consisting of Kovar-to-glass (as used on sealed tubes) surrounded for additional strength by a porcelain insulator.

The increase of ratings to 1500 or 3200 volts is particularly attractive for railroad service where higher voltage d-c operation is becoming increasingly popular. The new ignitron offers a more efficient power supply, without moving parts, is compact, light in weight, and demands little maintenance.

The Single-Phase Induction Motor—Modern Model

LAST year these pages gave notice of a greatly improved polyphase induction motor. Now we have an important sequitur—a single-phase squirrel-cage motor equally superior to its predecessor. The new capacitor-start motor is not only a wholly new design but also it profits from the thinking that went into the polyphase Lifeline motor. It uses many mechanical parts and precision methods developed for the polyphase motor. Thus the single-phase motor greatly benefits from the precision tooling, standardized parts, and high-production methods that the greater activity of the three-phase motor could justify.

The new capacitor-start, single-phase motor is a long step forward over its predecessor in many ways. It is sturdier; its windings are more rugged; the bearings are pre-lubricated and require no attention for at least five years.

These qualities, aimed at fewer troubles and less need for attention, are difficult to measure. However, the improvement in performance is concrete. In fact, the starting-torque characteristics have been improved to the point that the new single-phase motor can more than compete with the repulsion-start, induction-run motor, which has long been used for tough-starting assignments like compressors. The repulsion-start motor still has higher break-away torque, but the new single-phase motor can bring up to full speeds loads that the repulsion motor can start but cannot accelerate. The new motor has high torque values all the way from standstill to full speed, something the repulsion motor cannot provide. Thus compressors can be driven by the simplest form of induction motor—the die-cast, squirrel-cage machine. It avoids the wound armature, brushes, brushholders and short-circuiting devices with their possibility of high-resistance contacts and variation in speed calibration. The capacitor-start motor is electrically reversible and its characteristics are fixed, not subject to change by brush shift.

A centrifugal switch of improved design manufactured under close tolerances is used on motors rated one to three hp inclusive at 1750 rpm and 1½ to 5 hp at 3600 rpm. On larger ratings or special mountings, to which the switch is not readily adapted, an improved relay is used. The switch consists of a rotating governor on the shaft that actuates a set of contacts in one of the end brackets. The relay is a multiple unit specially developed to provide protection against undesirable dynamic braking torque when the motor is de-energized. Proper performance of the motor and relay is obtained over a wide range of operating voltage.

The capacitors are mounted in the conduit box, a location easily accessible and providing a lower ambient temperature. This lower ambient temperature permits the motor to withstand greater abuse in starting.

A novel stator winding using lap-wound coils grouped to provide the required distribution was developed for this motor. Greater ease in winding leads to less mechanical abuse of the insulating materials and provides a more reliable winding.

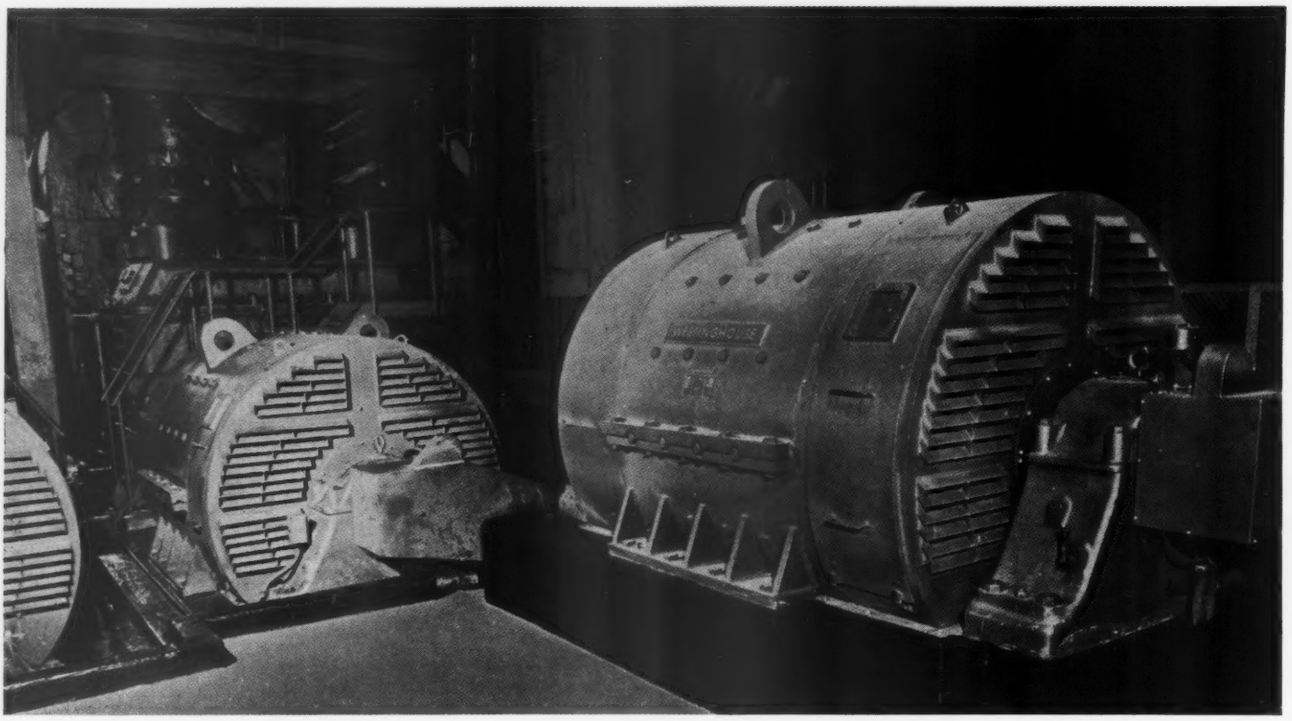
Inherent protection is available, when desired, by adding a thermoguard, which responds faithfully to the motor temperature, and is mounted in the frame under the conduit box. Either manual- or automatic-reset thermoguards are supplied.

The rotors of all single-phase motors are given a heat treatment after assembly. This burns off the punching burrs that provide short-circuit paths for eddy currents. The heat also gives a desirable annealing to the outer portion of the core. The net result is not only an improvement of 2 or 3 percent in efficiency and a 20 to 25 percent reduction in the cusp of the speed-torque curve but also greater uniformity of performance by successive motors.

Copper-Fin Design Means Smaller Motors

THE idea of copper fins extending from the stator core to improve motor cooling, mentioned here two years ago as an experiment, has been so successful as to culminate in a whole family of totally enclosed "copper-fin" motors. These now encompass the range of 125 to 1000 hp and may be extended even further. This design is based on the premise that accumulation of heat in the interior of a non-ventilated, totally enclosed motor can be avoided simply by using copper punchings spaced at intervals between the steel laminations. The copper is in intimate contact with the steel and conducts heat accumulated in the laminations from the interior to the exterior of the motor. By making the copper sections a few inches longer than the steel laminations, air

The five-hp, totally enclosed, a-c motor is no larger than the standard open motor of the same rating because of the use of silicone and other high-temperature insulations. The capacitor and protective relay for the new single-phase motor are in the conduit-box cover.



The last stand of Weirton Steel Company's mile-a-minute strip mill requires two motors of 4500 hp total.

circulated past these fins by a fan on the motor shaft removes this heat to the outside.

The copper disks occupy about the same space as do cooling air ducts on open motors and do an equivalent job of heat dissipation. Consequently, totally enclosed motors built on this principle are much smaller than the conventional type and in some cases can be built with the same mounting dimensions as an open motor of the same rating.

Copper-fin motors have been in successful operation for over a year on standard industrial applications and for driving power-plant auxiliaries, such as pumps and fans, where totally enclosed units are considered necessary.

Smaller, Better Mill Motors

MILL motors have been substantially improved. These are the motors that have the tough assignment of driving auxiliaries in steel mills where temperatures are high, gases often corrosive, and shocks severe. Recent improvements have resulted not only in a sturdier motor but also a smaller motor. A given rating is now in the next smaller frame size; thus a new 35-hp mill motor is no larger than the old-style 25-hp motor used to be.

Armature conductors are covered with glass yarn and impregnated with silicone. Thus only the new high-temperature materials are in contact with the hottest spots in the motor. New materials such as asbestos Micarta make it possible to hold the armature coils in place with wedges instead of by banding. This means that each coil is permanently locked in place immediately after insertion in the slot. The absence of coil banding avoids the chance of damage that may occur when a banding wire breaks with the armature turning at full speed. Also a wedged armature is simple to rewind.

The new, heavy-duty solid roller bearings are self-contained, require no auxiliary thrust washers or collars, and permit end play without the outer races moving in their housings. Split brushes, i.e., brushes divided lengthwise, give better commutation—simply because better contact with the commutator is assured.

Field coils are wound on a form but are not impregnated until placed over a hollow steel shell. Thus are combined the better insulation of form construction with the rigidity that comes from assembly on a final steel core. The use of four smaller interpoles instead of two larger ones improves commutation and permits use of a comparatively larger armature. In fact, although the frame size for a given rating is reduced, the size of the armature remains as before. An improved air-circulation system provides more rapid heat transfer from the armature to the frame and consequently more effective cooling.

Biggest Motors for Biggest Pumping Project

THE West is noted for irrigation projects in the grand manner but even among these the one in the Grand Coulee area will be king-size and breathtaking in concept. The half-million acres to be brought under cultivation are about 200 feet above the Columbia River level. The motors required will be more than half again as large as the world's present "biggest," the 40 000-hp Westinghouse induction motor at Wright Field. They are 65 000-hp, 200-rpm synchronous motors and will drive pumps to lift water from the Colorado River a normal total of 270 feet with a 360-foot maximum. The motor size was chosen in an interesting fashion. Because a single pump could not be built large enough to utilize all 108 000 kva of a single generator, it was decided that one generator would drive two pumps.

Each pump will deliver, at 310-foot lift, 1350 cfs, which is a fair sized river in itself. It is equivalent to a stream 6 feet deep, 45 feet wide, moving 5 fps. The eventual 12 units at work are expected to pump 4 million acre-feet of water per year. But if run continuously at full load they would pump three times this quantity, enough to inundate yearly the entire

State of Washington, wherein they will be located, under more than three inches of water.

These motors physically resemble vertical waterwheel generators but their electrical characteristics must be quite different. For one thing, they require especially heavy damper windings since, as an alternate measure, they can be started as induction motors by cutting off the water and the d-c excitation from the waterwheel generator and permitting it to coast down to 65-percent speed. Two motors, without excitation, are then connected to the generator after which its d-c field is applied. The generator slows down as the motors gain speed, and when the speeds are similar, the d-c fields of the motors and generator are applied and water is readmitted to the waterwheel. Normal starting is to connect two motors to a generator, all at standstill and with fields applied, and to admit water to the turbine, thus bringing motors and generators up to speed simultaneously.

Eight hydraulic jacks operated by oil pressure will raise the motor and pump rotors to provide access to the thrust bearing. To reduce coasting time, the same cylinders used for oil can be operated by air at 100 pounds, which forces brake shoes on the rotating element against a stationary brake ring.

Refineries Use Nitrogen-Cooled Motors

NITROGEN is being added to the list of motor coolants. Several motors employing it are being built for a large oil refinery. These are big motors—2250 hp at 1800 rpm, the largest explosion-resisting squirrel-cage motors to date. They are so large that reliance cannot be placed on the ability of the motor walls to resist bursting should an explosion occur inside, as is done with smaller motors. Hence explosive gases and air must positively be excluded. The motors will be connected to a supply of nitrogen or other inert gas and an internal pressure maintained slightly above atmospheric. A separate motor-driven oil pump maintains the oil seals around the shaft when a motor is running or shut down.

A Motor for Industry's No. 1 Tough Assignment

IF awards were to be given the industry that has the toughest job for a motor the palm probably would go to pulp making. Few drives, if any, make as severe demands on their motors as the one for log chippers. This machine with a set of revolving blades chips logs into small pieces for the chemical digesters that reduce them to pulp. Here the logs are fed one, two, or more at a time through a chute down against the side of a blade-carrying disk. Many times per second the load may vary from zero to seven or eight times full load. No ordinary motor can long withstand the severe shocks that are the regular diet of the chipper motor.

Tailored for this service is a new synchronous motor possessing unusual features. This motor, of uncommonly massive construction, is to drive a chipper with a 175-inch wheel capable of handling logs 30 feet long by 4 feet in diameter. The motor stands 12 feet across its outside diameter and is rated at 1500 hp, 240 rpm. A starting torque of only 60 percent full load is used, which keeps the inrush current and its heating effect low. The rotor, with damper bars of Monel metal, is forged of steel instead of being cast or fabricated. It is purposely massive to withstand the shock and vibration and to contribute a large inertia of two million pound-feet squared. This enables the motor with a pull-out torque only three times rated torque to withstand loads that may approach eight times normal.

Tin Plate at a Mile a Minute!

RISING costs and demands can be met in one way—by providing machines that produce more! To this end Weirton Steel Company and rolling-mill equipment manufacturers have cooperated to build a tin-plate mill that produces a sheet 38 inches wide at the breath-taking speed of 5000 feet per minute. Speeds of 3800 feet per minute have been considered fast heretofore with 2000 feet per minute as more common.

The electrical drive for this mill requires a total motor capacity of 17 550 hp, more than double that used on older mills. To provide sufficient power for quick acceleration, the fifth stand employs two 2250-hp motors (a total of 4500 hp) more than is known to be in operation on any single stand of this type. All motors and main motor-generator sets are installed in the mill building without protection of a separate room and are therefore equipped with front and rear enclosing covers and arranged for forced ventilation. Ventilating air is supplied by a Precipitron electrostatic air cleaner having a capacity of 375 000 cubic feet per minute.

An unusual feature of the electrical equipment is the control board, which permits complete control of the mill from a single point of supervision. Indicating and recording ammeters and voltmeters and tension indicators advise the operator of any abnormalities in the operation, and control switches permit him to take necessary corrective measures.

A Generator for Each Motor

SPECIALIZATION increases. Each of the motors in some tandem steel strip mills and on the sectional drives of certain large paper machines has its own individual generator. This is warranted because the horsepowers of single motors are becoming so sizable and because of the resulting simplification. It is not uncommon for some drives of a multiple-stand cold strip mill to be rated at 4000 hp, and with the new 5000-fpm, 42-inch-wide mills looming, some may draw 7500 hp. Instead of supplying the d-c driving motors from one large m-g set, each is to have its own generator, whose voltage will be controlled to suit precisely its needs. Now that the motors do not draw from a common d-c bus, IR-drop compensators can

Workmen complete a 25 000-hp wound-rotor induction motor.

be eliminated. These compensators are sizable and expensive rotating machines because, while they do not handle much power, their commutators must carry currents of 5000 to 8000 amperes. Also the individual-generator scheme reduces the interrupting capacity required of circuit breakers.

Individual generators are being used for the sectional-drive motors of paper machines for pretty much the same reason. Precise, synchronized speed control, so essential between the sections of paper-forming machines, can be better achieved if the generated voltage can be tailored to the needs of each particular motor. Also with paper-machine speeds rising—2000 fpm has been achieved; 2500 fpm is being talked about—sectional-drive motors are growing.

Bigger Dual-Circuit Generators Coming

REALLY two-in-one is the dual-circuit generator, in which two independent circuits are built in the same frame and wound on the same armature. Used on electric shovels and draglines for open-pit mines and quarries, it is smaller than two separate single-circuit machines, which saves space.

Electric shovels and draglines, in which most dual-circuit generators are used, employ three motors or sets of motors, one for each of the hoist, crowd, and swing motions. In some cases, a dual-circuit generator supplies both the crowd and swing motors, which are usually of the same rating. The two output circuits, although they have the same armature conductors, can be varied independently by separate fields to supply different voltages to the driving motors, which will therefore run at different conditions of speed and load as desired by the operator. This could not be accomplished with a single generator except one of the dual-circuit type. In recent years, particularly in the larger excavators, it has been advantageous for mechanical reasons to use two crowd or two swing motors. Here again, a dual-circuit machine makes it possible to have only one generator for each motion and also insures that the motors properly share the load.

Dual-circuit units have been limited in size by two factors. First, commutation, which becomes increasingly difficult as the size increases; and second, interference between the two circuits (more pronounced in larger machines) causes a voltage change in one to be reflected in the others, resulting in undesirable speed changes in one or both motors. By simply rearranging and redesigning the fields and incorporating improvements to better commutation, previous restrictions have been overcome. A new family of dual-circuit generators is produced, which reduces the size for a given rating and provides greater flexibility of operation and control. For example, it is even possible to reverse the polarity of one of the circuits without affecting the other.

This 9.24-hp, 3600-rpm motor weighs but 54 pounds. It drives an air-conditioning compressor for one of the largest transport airplanes and is explosion resisting.

Enclosed Motors No Larger Than Open Motors

THE ideal electric motor would be completely sealed. It would thus be independent of troubles that arise from deteriorating gases, dirt, lint, or metallic particles drawn in with cooling air. The problem is that "ole debbil," heat. One solution is to make the motor bigger so it will have more radiating surface, but there are several things against that. Another approach is to let the motor run hotter and use materials that are not damaged by higher temperatures. That possibility is being aggressively explored, using the newest silicone insulations. Some success has already been registered.

By using glass-covered wire, silicone-treated material for slot cells and phase insulation, and silicone grease in the bearings, and by dipping and baking in silicone varnish, three- and five-horsepower motors totally enclosed have been built in almost identical overall dimensions, as are standard open motors with class-A insulation. The problem becomes more difficult as ratings go up but engineers are hopeful that motors larger than five horsepower can be totally enclosed without increasing housing dimensions.

A-C Supply, D-C Drive

THE combination of a-c supply and d-c motors for industrial drives is hard to beat. At least two ways of operating d-c motors on a-c lines using rectifiers are currently highly successful. In one the intervening link is the selenium type of dry-disc rectifier. The other is a controlled tube-type rectifier. The selenium-rectifier scheme is simpler, but does not give as wide a speed range (it furnishes only a constant d-c voltage) or as close control as the tube.

The selenium rectifier is being used for six sizes of 230-volt motors between 1 and 15 hp. The rectifier, controls, autotransformer, and (in the larger sizes) a fan to keep the stacks cool are housed in a small cabinet, which is placed at any nearby convenient location. Selenium rectifiers bring about a significant saving in size and weight, as compared to the copper-oxide type or to motor-generator sets.

The metallic rectifier allows use of conventional d-c control. However, on the 1- to 7½-hp sizes, its natural internal resistance makes it possible to omit d-c starting control and retain only the barest essentials—a standard a-c linestarter and a field rheostat. Either reversing or dynamic braking are obtained readily. Voltage and speed regulation using the rectifier are comparable to that with a motor-generator set. Commutation, which one might expect to be adversely affected by the rectifier ripple, has proved to be excellent in months of actual operation on a variety of machine tools.

The tube-type d-c motor control, called Mototrol, appeared several years ago and has recently undergone a working-over in accordance with industrial practice. The result has been some simplifications, a reduction in the number of tubes for certain sizes, and the substitution of industrial-type components in place of the radio-type, wherever possible. For

Copper punchings interleaved between flux-carrying stator punchings utilize the conductivity of copper to cool the motor.

example, Inerteen-impregnated condensers have replaced the paper type; industrial relays, the telephone type.

One new use for Mototrols, which indicates the rugged service to which they are being exposed, is in steel mills to drive alloy strip through annealing furnaces and pickling tanks. The power requirements are small, 3½ to 7 hp, but the speed must be adjustable and closely regulated over a wide range—much more than the four-to-one possible by field control of a standard d-c motor. Mototrol power supply and control equipment are all stationary and are contained in a small cabinet. The drive is excellent as it gives precise speed control over the 4 to 32 feet-per-minute speed range of the processing line and a 2½ to 1 speed adjustment as the strip being wound on the reel increases in diameter. By both field and armature control a speed range of 20 to 1 is obtained. The performance to date of over a dozen Mototrol drives on these processing lines has been eminently successful.

Electric Power Aloft

ELECTRIC power for airplanes is crystallizing into three definite systems. These are the 24-volt d-c,* 120-volt d-c, and 120/208-volt a-c. The three, furthermore, illustrate widely different stages of development. The low-voltage d-c system has been at hand many years—and will continue to be for all but what is now considered the largest aircraft. This low voltage has reached the evolution stage where it is undergoing equipment refinements. The a-c system began to receive attention early in the recent war and has undergone considerable development. It is now being built in quantity for several types of large planes. By the fall of 1947 some units had been installed. The high-voltage d-c equipment, least well developed, is still in its early stages.

The outstanding thing of note in the 24-volt d-c system is the trend to generators of higher speeds and power outputs and to the development of much better control and protective devices. The war was fought with the P-1 generator of which several hundred thousand were built for the air services. The P-1 delivered 200 amperes and operated at a speed range of 2500 to 4500 rpm. Now on the production line are 300-ampere, 30-volt generators for the much wider speed range of 3000 to 9000 rpm as well as a 200-ampere, 4000- to 9000-rpm generator. Developmental low-voltage generators have been built in ratings of 400, 500, 600, and 800 amperes, but, before these can be utilized, a number of problems remain to be solved. For one, these generators are too large to mount directly on the engine, a problem which may be solved by a possible intermediate development, the so-called "remote drive shaft." This will permit the generator to take power from the engine but without having to attach it directly to the engine.

For the low-voltage d-c system a new overvoltage relay provides a superior degree of protection. The requirements of overvoltage relays for aircraft service are critical as the wide speed range of aircraft generators results in a high transient voltage during some switching conditions. The overvoltage relay must not give nuisance trips during switching surges (which may be as high as 70 volts) and yet it must give reliable overvoltage protection in the range of 31 to 33 volts with an operating system voltage of 27 to 28 volts.

The 40-kva, three-phase, constant-speed alternator, whose development was mentioned in previous editions, is now in production. The weight of the production model is 10 percent less than the prototype (75 pounds instead of 83) or less than two pounds per kva. Also on the production line is a single-phase, 8-kva, 120-volt, 400-to-800-cycle alternator and another variable-frequency alternator to supply 11 kva to a three-phase, 120/208-volt network.

The a-c system is first being applied to such big ships as the B-35 and B-36. First deliveries have been made of the B-36. The 400-cycle system, whose major components are pretty well worked out, presumes a constant-speed torque converter. A hydraulic model, built by Sundstrand Machine Tool Co., is used on the B-35 and B-36. The generators and network equipment, including switches and protective devices patterned after big-city secondary-network practice and utilization equipment, have reached an advanced stage of development.

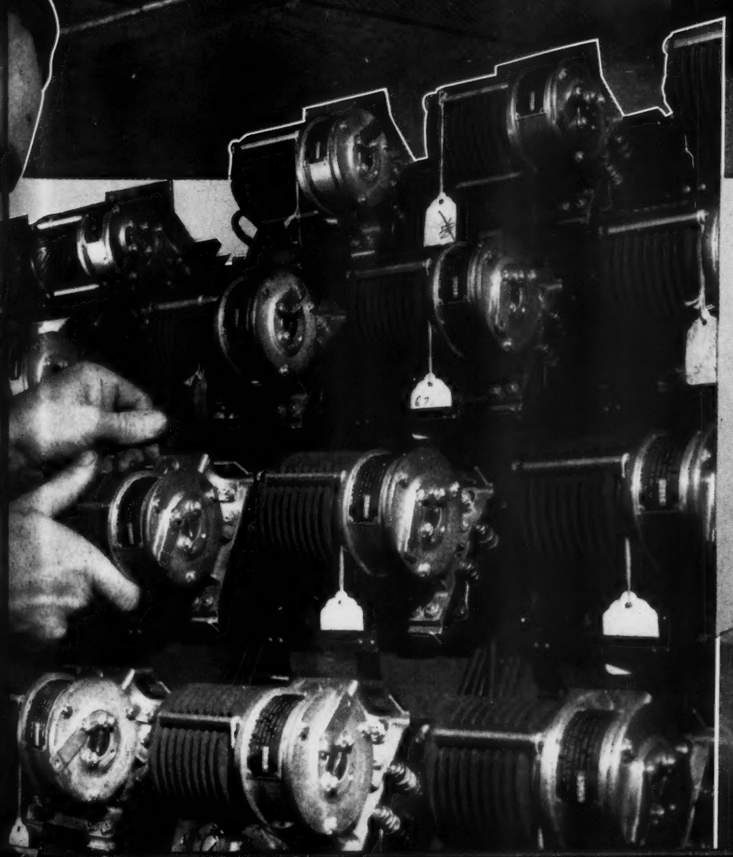
(Continued on p. 18)

Combination trolley-supply and battery locomotives for open-pit metal mines are not unusual, but this one employs a Diesel-electric power system for use beyond reach of overhead lines instead of the usual batteries.

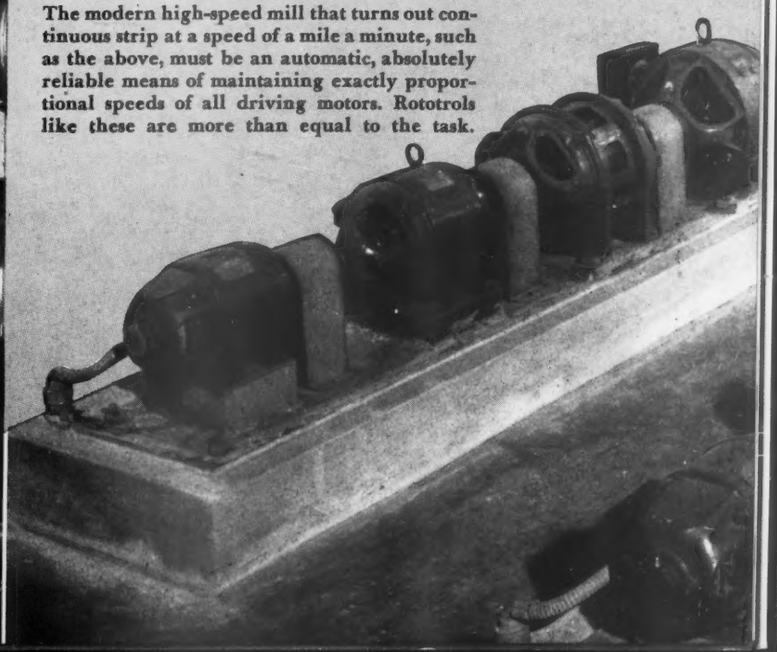
*The low-voltage distribution system is designated as 24 volts, officially set by standardizing bodies. However, the actual voltage at the regulated point is still 28 volts.

From this seeming mountain of all-steel deep-drawn parts comes the end bells for either the polyphase or single-phase Lifeline induction motors. The new single-phase motor is much improved because it utilizes many actual parts and production methods devised for the high-volume polyphase cousin.

Heart of new controls for aircraft power systems is a carbon-pile voltage regulator that holds generator voltage constant irrespective of changes in connected load or speed.



The modern high-speed mill that turns out continuous strip at a speed of a mile a minute, such as the above, must be an automatic, absolutely reliable means of maintaining exactly proportional speeds of all driving motors. Rototrols like these are more than equal to the task.



The most significant trend observed during the past year has been the vastly increased emphasis on system coordination and protection. This goes hand in hand with the ever-increasing dependence of large aircraft on electrical power for essential flight operations. Maximum ratings are still climbing and efforts are under way to achieve successful operation at higher and higher speeds so that increased output can be obtained with little or no additional weight.

Of the three systems available, preference of the airplane builders appears to be for alternating current but this is at present tempered by some skepticism as to the degree of completion of the development work. The 24-volt, d-c system is still the choice for most new airplanes and very few airplane manufacturers appear to be ready to use the 120-volt, d-c system. This system is intended as an intermediate stage for airplanes too large for 24-volt systems but not large enough to warrant the complexity of the complete a-c system. It will probably be at least two years before any extensive use is made of 120-volt equipment and such use may never come if experience with the a-c system is as satisfactory as is hoped.

New Motors for New Aircraft Jobs

THE rapidly expanding electrification of aircraft has brought into being a large family of motors, having numerous interesting functions. The size of some of these is a bit startling. The largest one thus far develops 9.24 at 27 volts direct current and runs at 3600 rpm to drive an air-conditioning compressor on one of the big commercial airliners. It weighs but 53.5 pounds. (A standard, open 10-hp, 3500-rpm d-c motor weighs 255 pounds). It is explosion-proof, with a ventilating system of its own by which air is drawn from the outside, circulated through the motor, and vented to the outside. Another large d-c motor is a 7½-hp, 115-volt unit running at a speed of 5800 rpm.

Indicative of the unusual tasks to which motors are sometimes put in aircraft is one of ⅓ hp mounted within the hub of a whirling propeller and used to vary its pitch should the normal hydraulic control fail. The motor is submerged in oil, runs at 11 000 rpm, and operates on 400 cycles. Centrifugal forces subject it to stresses as high as 400 g.

About two years ago a family of standard, general-purpose d-c motors was developed especially for airplane use. These have been directly applicable to many jobs, thereby achieving the various benefits of standardization. In some cases only minor modifications have been required to match the standard motor to a particular job. For example, by providing the 3⅛-inch-diameter motor with a special bracket, one pump manufacturer was able to build within the wing tanks supplemental fuel pumps submerged in and cooled by the gasoline itself. The motor operates at either of two speeds. For normal pumping, it turns at 6500 rpm and delivers ⅙ hp. During take-offs and in case of main pump failure, it runs at 9000 rpm with double the power output. The same motor, with a gear, drives a pump to transfer gasoline from one tank to another while in flight.

The 4-inch standard motor is being adapted to develop 0.6 hp as a fuel-pump drive for the jet engines in P-45's. A smaller motor (it is 2$\frac{5}{16}$ inches in diameter and develops $\frac{1}{50}$ hp on 12 volts) with a built-in brake and 434:1 speed reduction is used to control a wing flap.

A self-regulating motor-generator set has been developed to supply two closely regulated voltages for a highly accurate, radar-type altimeter. The set with its carbon-pile regulator delivers 12.8 and 270 volts with less than five percent plus or minus deviation for any impressed voltage between 19 and 30 volts. This insures instrument accuracy regardless of the voltage level of the plane's 24-volt system.

Another special motor-generator set provides constant frequency (400 cycles) and substantially constant voltage with constant load impedance. This is accomplished by using a permanent-magnet excited alternator and a special constant-speed coupling between motor and alternator.

New dual-circuit generators are produced for shovels and draglines. Improved field windings reduce restrictions to rating set by commutation and interference and give better operating flexibility.

Electric Motors Propel Locomotive Cranes

CULMINATING ten years of development, the American Hoist and Derrick Company has placed in production a Diesel-powered locomotive crane equipped with railway-type d-c generator and motors to provide the propulsion force. Other crane motions are, as before, powered directly from the Diesel through mechanical linkages.

Prior to this development, propulsion of crane locomotives was accomplished by a series of gears that transmitted power from the Diesel engine in the rotating cab through the center pin to the driving axles. With electric propulsion, tractive effort at the rails is developed by two totally enclosed d-c series motors driving the axles through a single set of gears. By eliminating mechanical propulsion through the center pin and with it most of the gearing, the new electric drive results in reduced noise, maintenance, and operator fatigue.

The crane, which weighs 115 tons and has a lifting capacity of 50 tons, can be moved by electric propulsion at a maximum speed of approximately 15 miles per hour. It may also be placed in a normal freight train and towed at 35 miles per hour. The heavy-duty traction motors need not be disengaged to avoid damage by excessive speed.

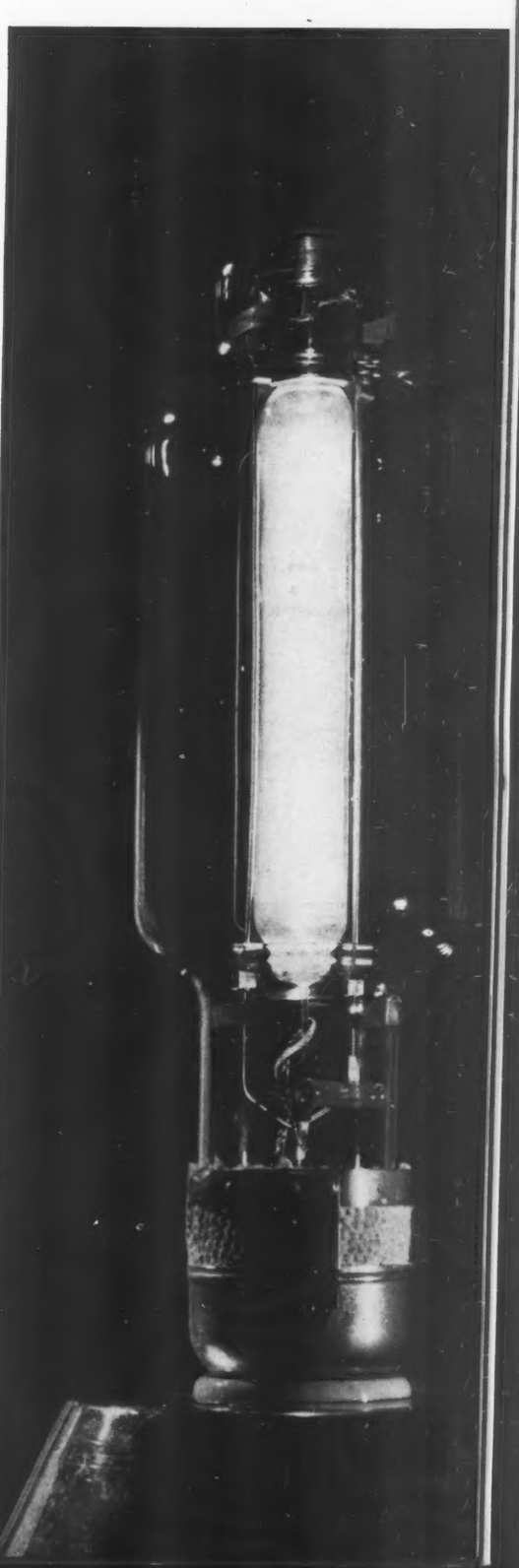
Illumination and Electronics

Cadmium-Mercury Lamp—New Movie Star

MOTION-picture actors and actresses have been performing in the brilliant light of carbon arcs since the founding of the industry. Because of the enormous amounts of light required filament lamps have offered the arc lamp but small competition. The arc lamp was further entrenched as a light source for movie sets when color arrived, with its four times greater light requirement and its necessity for good color.

However, a new lamp has appeared, forerunner of more powerful lamps to come, that will challenge the carbon arc. It is a cadmium-mercury discharge lamp with a high-intensity arc in a quartz bulb. The test lamp is the 1000-watt mercury-vapor lamp recently introduced for lighting high-bay areas of factories. To this lamp was added a small controlled amount of metallic cadmium, which provides the red color lacking when mercury vapor is used alone. Physically the lamp is a quartz arc tube contained in a hard-glass envelope 14 inches long and 3½ inches in diameter.

These new lamps must undergo a rigorous gauntlet of development and testing before their application by the motion-picture industry for general set illumination, although the results of the first tests with color film were successful. The cadmium-mercury lamp will simplify studio-set lighting. It is an enclosed, self-contained lamp, requiring no attention throughout its life. (Carbon electrodes must be changed every couple of hours.) It emits no smoke or fumes and it is silent—both of great value in the production of color-sound movies. Because of the high efficiency of vapor lamps, the heat dissipated for a given amount of light is small—a matter of great importance to the comfort of the actors.



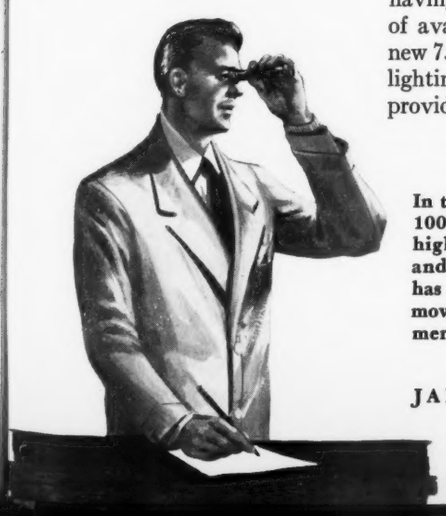
In the mercury-vapor lamp family is this newcomer, a 1000-watt size that is being used successfully to light high-bay factory areas. With only slight modification and by the addition of cadmium to improve the color it has been used with success in color-film test work in movie studios. It is the harbinger of other cadmium-mercury lamps for use in the motion-picture industry.

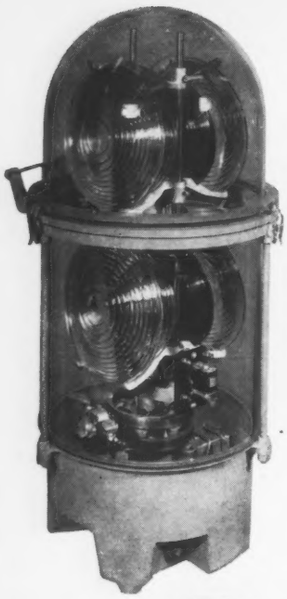
The Growing Family of Lamps

THE already enormous family of electric lamps continues to be prolific with the addition of many new members in the past twelvemonth. Most of them have been unspectacular but very important for the functions that brought them into being. Here are some samples.

For the farmers, more and more of whom are operating tractors at night, a special tractor headlight has been developed. It is a sealed-beam type, only five inches in diameter, and has a special lens to provide an 80-degree horizontal by 20-degree vertical dispersion. This is much broader than the automobile sealed-beam lamp because the need for avoiding glare is absent and because the light is aimed downward to cover well the area only a few yards in front of the machine.

Several varieties of standard voltage, internal reflector spot and flood lamps have appeared. One is the 300-watt edition with a hard-glass bulb so that it can be used in the rain. This is double the wattage previously available in this line of lamps having heat-resisting glass bulbs. Extending the size of available internal-reflector lamps downward is a new 75-watt lamp in a smaller bulb suitable for flood-lighting and spotlighting where intensity less than that provided by 150-watt lamps is satisfactory.





In a cylinder and dome of glass is the revolving beacon for small airports. With two-lamp and two-lens system it provides a powerful beam of maximum reliability and least possible maintenance. The new high-intensity threshold and marker light (center) for airports produces maximum candlepowers 100 times greater than those from semi-flush units now in use. Three lamps, one on top for use when visibility is good and one in each end of the drum-shaped housing for use when fog hangs low, all of which are controllable over a wide range of intensities, give a marker light adaptable to every weather occasion.

Fluorescent lamps combined with spotlights and arranged to suit the counter pattern, instead of being symmetrical with the building columns, make active use of light as an aid to store-traffic control. To bring attention to merchandise in cross aisles, these areas, usually neglected, are more brightly lighted. Additional illumination at the rear of the store helps dispel reluctance of customers to walk to the far-end counters. The spotlights can be altered as merchandising changes to emphasize and highlight certain featured goods.

To provide a better light source for measurement of distance to clouds at airports and weather bureaus is a new mercury-vapor lamp with a concentrated arc ¼ of an inch long but with an input of 1000 watts.

A half-circle lamp, the Circlarc, has been added to the domestic fluorescent family. The circular fluorescent lamp, introduced two years ago, has been very popular, particularly for bridge and reading lamps. The complete circle, however, is difficult to make and difficult to install where more than one is used in the same fixture. To supplement it a new fluorescent lamp in a 180-degree arc has been developed. This lamp is more adaptable to mass-production machinery and uses a small inexpensive ballast instead of the more costly transformer necessary with a circular lamp.

Two Circlarc lamps can be readily mounted so as to form a full circle 12 inches in diameter. The Circlarc lamp is also significant to the user in that it gives him a pleasant and versatile new form in fluorescent lamps. To the lighting equipment manufacturer it is important because it makes it possible to use a standardized fluorescent lamp in new ways, such as in half-round desk lamps and wall fixtures, in pattern lighting on ceilings and walls, around center columns or display pieces and to round off the ends of commercial fluorescent fixtures.

Help, via Light, for the Small Airport

ABOUT 3300 airports are in operation in this country. Only 600 of them are lighted. The 2700 unlighted ones do not include any of the super-airports, nevertheless the aggregate amount of air traffic, particularly private flying, they handle is enormous. Yet these fields, which represent large investments, are usable only in daylight hours.

One reason more of the middle-size and small landing fields have not equipped themselves for night flying is, frankly, there has been almost no suitable equipment available. Obviously they cannot afford the equipment required by major-city fields, but the requirements for safety can be no less strict.

Engineers have set about to provide a family of apparatus suitable for use with small airports. This has been a major problem as it is not possible to answer the need simply by making small-scale or cheaper models of the apparatus used by the Idlewild's and Washington National's. It entails entirely fresh design, sometimes new principles. Construction must be quite different, with rigid adherence to economy. Also the equipment must be virtually foolproof, require a minimum of maintenance, and no special tools for servicing, as it must operate without attention from specially trained maintenance personnel.

Junior airport equipment that has grown out of these objectives includes a rotating beacon, wind cone, obstruction lights, and runway marker (contact) lights. They provide all the necessary functions of the super-airport equipment, but at about one third the cost.

The Junior rotating beacon is representative of the engineering entailed by the new equipment. The beacon standard for large airports (class E) is a horizontal drum with 36-inch lenses in each end, the whole thing rotating in prescribed CAA fashion. It has an elaborate, efficient lens system and an automatic lamp-changer mechanism that swings a spare lamp into the focal point literally quicker than a wink should the first one burn out. The problem for small airports was to achieve these features with a less powerful beam and at much less cost. The result is an assembly of two lamps and simple lenses rotated within a stationary glass housing. Thus all rotating parts are enclosed. Instead of providing the more

complicated and costly automatic lamp changer it was both cheaper and better, from a maintenance view, to use two lamps, each with its pair of lenses, and switch power from a dead lamp to a spare by a simple relay. Identical lenses can be placed in the holder in only one way; incorrect adjustment of changer mechanism is impossible, and no parts are exposed to the weather.

The Junior wind cone has all the features of the large unit for major airports, but servicing has been simplified to meet facilities available at small airports. The assembly is very light and is mounted on a hinged pole, so instead of climbing up to relamp and lubricate, the whole unit is easily lowered to the serviceman.

Junior marker lights give photometric performance equal to the larger and more expensive types, but use standard screw-base lamps instead of those with special bases.

X-rays Measure Thickness

ONE of the great unsolved problems of high-speed manufacturing—the indication of thickness of a rapidly moving and often very hot product without touching it—seems to be on the verge of an answer. X-rays hold high promise of solving this toughie. A device employing such rays has been developed and was applied last fall in a Pittsburgh mill to gauge steel strip as it emerged from the finishing rolls. It is now undergoing practical mill trials.

The scheme, in essence, consists of two x-ray tubes, set at right angles, one "looking" through a standard thickness of metal, the other through the moving sheet to be gauged. Radiations passing through both the sample and the production sheet fall on a common x-ray detector, which generates current proportional to the amount (which, of course, varies with thickness). The two tubes rapidly alternate in production of x-rays so that in effect the device compares, at a high rate, the thickness of the moving sheet with that of the standard. In this way temperature, voltage, drift, and other errors are automatically eliminated. The resulting x-ray detector current is amplified and fed to a direct-reading instrument that indicates the difference.

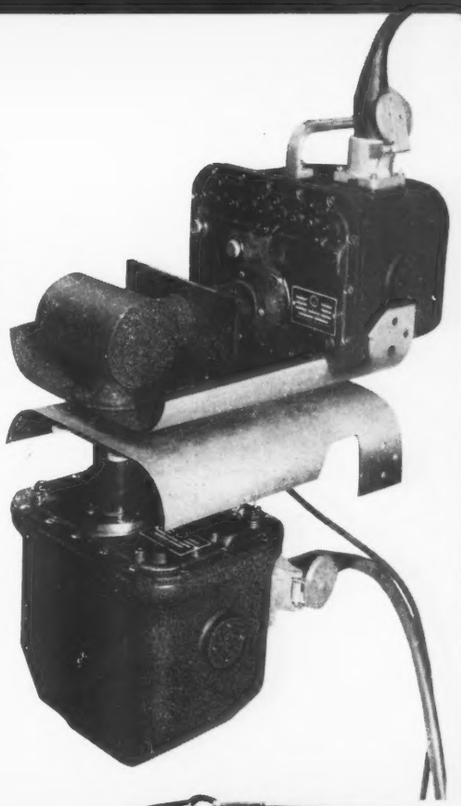
Laboratory tests of x-ray gauging indicate that phenomenal accuracy can be obtained—although such accuracies in practice may not be desirable or practical. Tried on thicknesses from 5 to 15 thousandths of an inch, full-scale instrument deflection is obtained for only one thousandth deviation; thus a one ten-thousandth change from standard is easily detectable. The gauge can thus detect thickness change equal to an almost imperceptible surface scratch. Accuracies better than one percent have been obtained in the laboratory.

X-raying Is Simplified

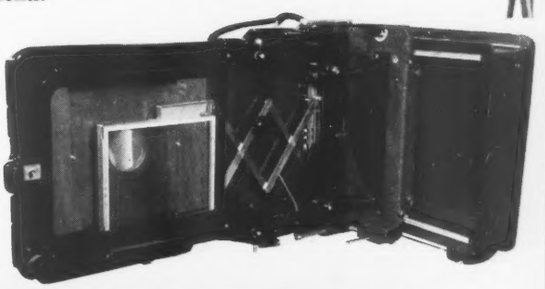
JUST slightly over a half century ago Roentgen provided the physician with a tool that ranks in importance with antiseptics and anesthetics—the x-ray. In the 50 years since, the principle has remained unaltered although untold time and research have gone into improving its usability. That x-ray equipment engineers continue still to be successful toward this end is indicated by several representative technical accomplishments of the past 12 months.

Engineers reason that the x-ray technician should be allowed to direct his full attention to the patient and the mechanics of operating the tool should absorb the barest minimum of effort. The 250-kv therapy machine for treatment of deep-seated ailments is a case in point. For several years, it has been an extremely useful machine, consisting of a power-

Here is the mechanism that is able to measure the thickness of fast-moving steel strip without touching it. X-radiation through a standard and through the production sheet are rapidly compared electronically, the result amplified, and an accurate indication provided on an instrument.



A new mechanism permits one, two, or four x-ray exposures to be made on one film in improved arrangement and greater simplicity. A new x-ray machine (bottom) brings to the small office great flexibility for the wide variety of work that comes to it, without the need for a group of specialized x-ray equipments.



ful x-ray tube in a head extending from a pair of vertical columns over the treatment table. The tube head is heavy, weighing about 300 pounds, and must be readily movable in three directions. Because of this weight the therapist has previously been required to go behind the table to the supporting columns to raise or lower the therapy head. Considerable physical strength was required to operate some of the motions.

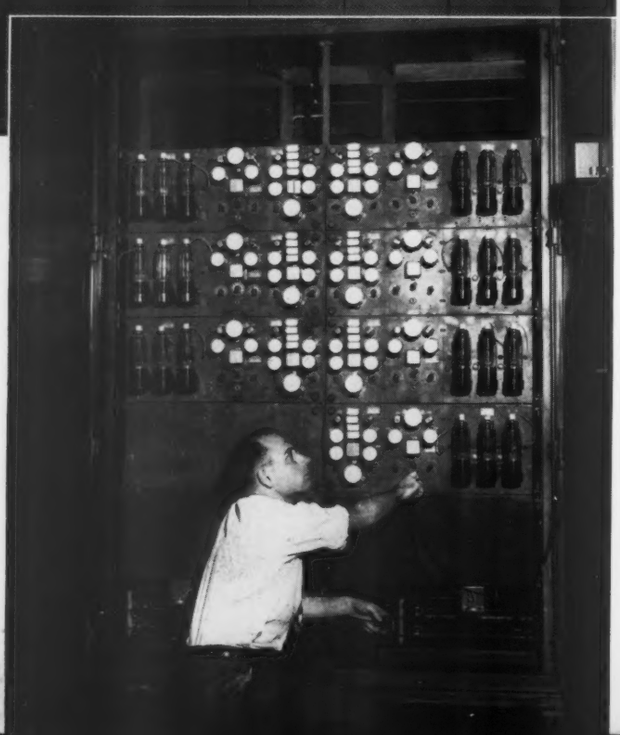
By careful reconsideration of mechanical design almost all attention-diverting aspects of the unit have been eliminated without much outward change in appearance. Redesign of ball bearings reduced friction by half so the head can be operated without strain from the operating side of the table. A small knob provides micrometer-like adjustment of the therapy head position—not previously possible. In short the therapist now thinks only about treating the patient and not about the mechanism.

A completely redesigned version of the so-called four-in-one spot-film device also typifies the general trend in x-ray simplification. The complete apparatus on which this device is used consists of a table on which the patient lies and a fluoroscopic screen that can be moved above the patient's body. This enables the radiologist to observe any portion to be examined. Upon seeing something to record, he presses a button. A cassette (filmholder) slides into position and a picture of that area is taken. The four-in-one feature results from the fact that the operator can take four small pictures in succession on one film, or two half size, or one large picture using the whole negative. This saves film.

This feature is not new but for the first time this type of machine uses a full-size standard fluoroscope screen (12 by 16 inches) and 8 by 10 film. Also all four exposures are made right side up, which facilitates their study if they happen to be close-sequence pictures of some organ action. Unlike the previous machines, double exposures are impossible. The radiologist who, of course, is working in darkness need not attempt to remember what portions of the film have been exposed. Controls do not require touch discrimination for their operation; pressure of the hand alone is sufficient.

A new x-ray brings within economic range of the general practitioner four standard techniques: vertical and horizontal fluoroscopy and radiography. It consists of a table, x-ray head, fluoroscope, filmholder, and control, all built as a single unit that sacrifices none of the basic features of more expensive models required by specialists and hospitals. Only some automatic controls and features found on more de luxe units are missing. The table (called the RX) can use either the 15-ma head which contains, in a single unit, the tube, transformer, and rectifier, or the larger, more powerful 50-ma or 100-ma tube having separate power units. An entirely new mounting arrangement perfectly balances the table in a horizontal position for fluoroscopy, as well as in a vertical position or at an angle, or turned entirely over for radiography. This fulcrum principle for tilting the table reduces cost by two thirds, to extend widely the availability of fluoroscopy and radiography to the medical profession.

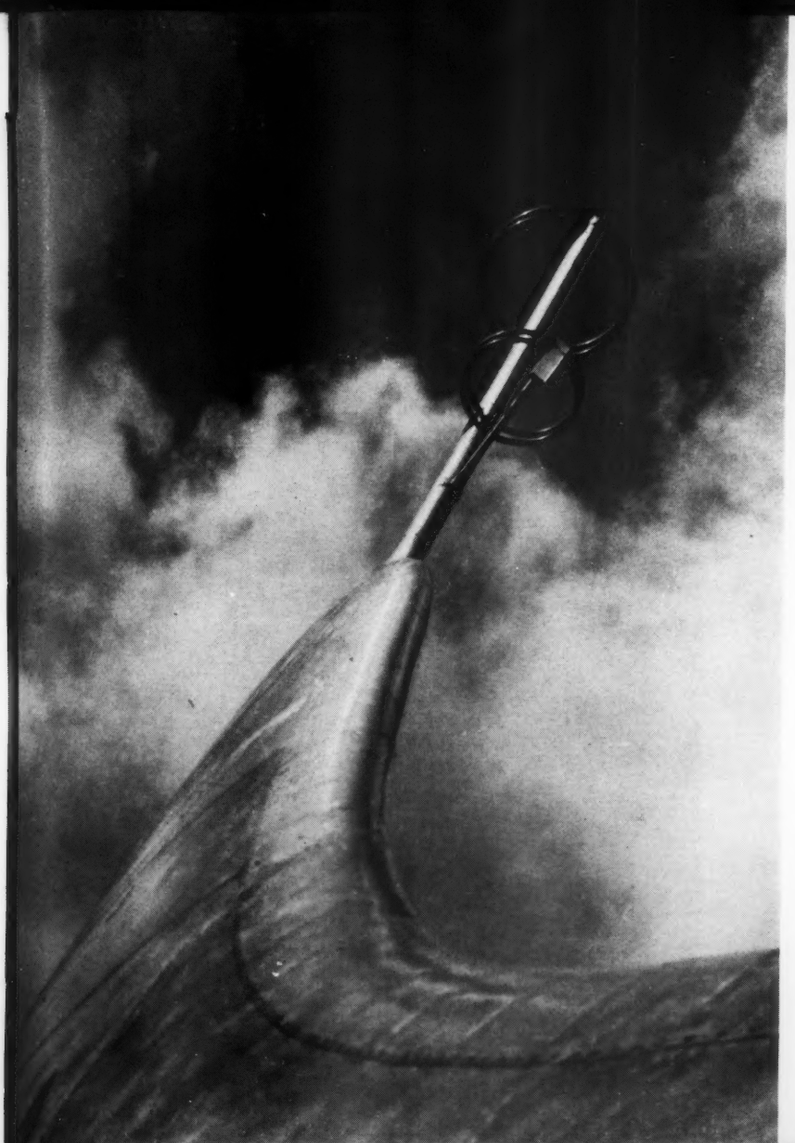
New types of point-to-point radio sets have been devised for places where construction of telephone lines is impractical or impossible, such as scattered fruit plantations in jungle areas, ship to shore, between air terminals, or from ground to plane. Compared to prewar sets they embody many improvements in components learned while building radios for severe service in all parts of the world, from steaming jungles to icy North. The new sets follow the building-block idea now being used so effectively with many equipments. By assembling standardized, coordinated cabinets for the different functions any desired type of radio communication can be quickly provided.



Aid to Dental X-raying

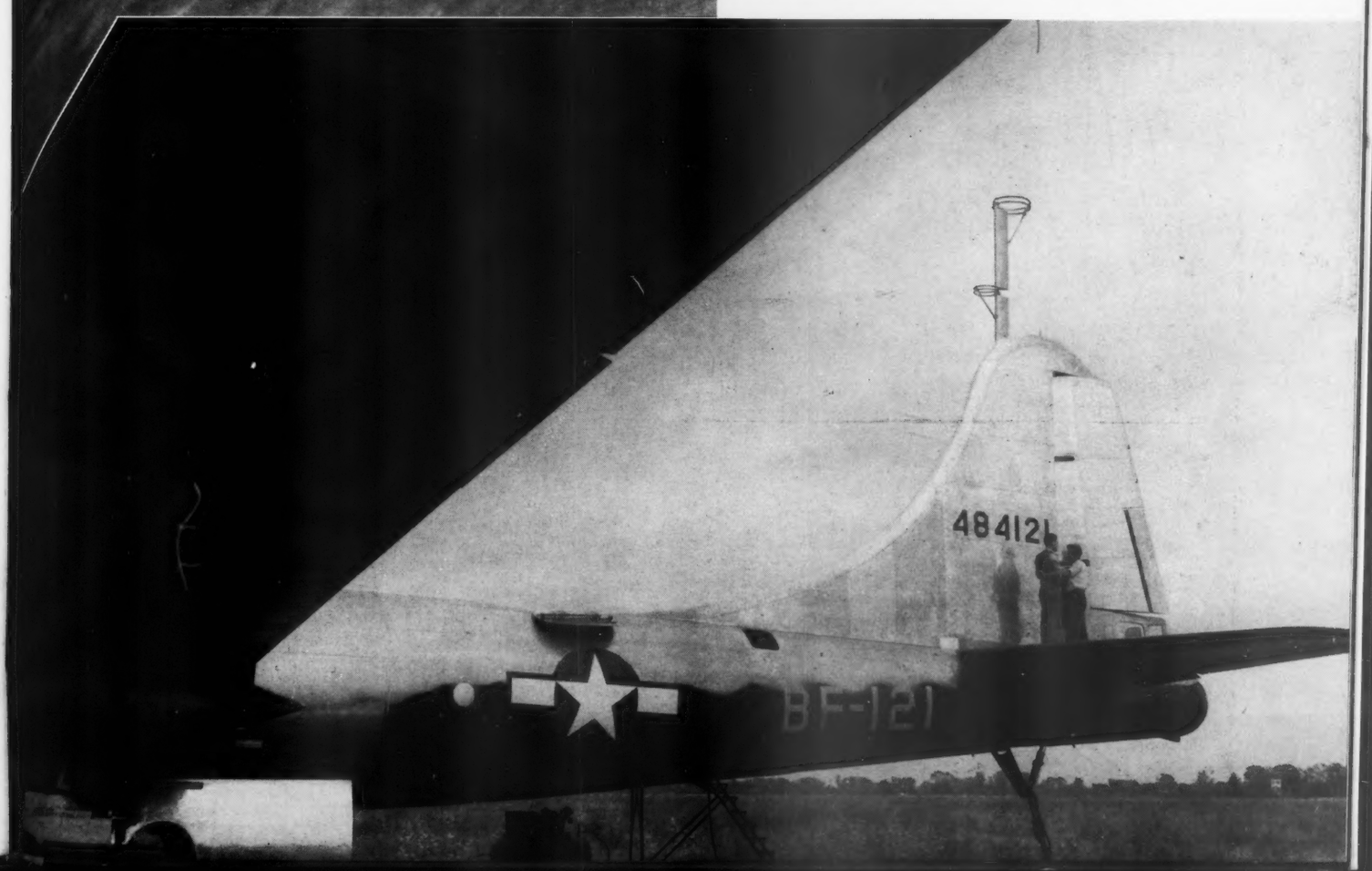
A NEW, tiny x-ray tube, small enough to be carried in a vest pocket, has many new engineering features of interest in addition to its diminutiveness. Intended primarily for dental and portable x-ray service, the 70-kv tube is a glass cylinder only 4¼ inches long by 1⅜ inches in diameter, which is about 15 percent less in each dimension than ordinary tubes. An 80-kv model is only slightly larger. A few quarters of an inch saving in tube dimensions multiplies to large savings in the total bulk of the enclosing head and its adjuncts.

Twenty minutes after the paper-making machine was connected to this electronic speed regulator a commercial run of paper was being made. Electronic regulators retain all of the features of the carbon-pile regulators, including field forcing, high-speed response, anti-hunting, and an infinite number of regulating points. They provide, in addition, increased sensitivity, higher speed of response, and broader control range. Also they eliminate the speed changer and the other mechanical parts associated with the mechanical speed differential on paper machines.



Trends and Developments

With the equipping of a converted B-29 with television and FM radio receivers and transmitters, Stratovision enters stage two of its development—that of re-transmission from high altitudes of radio programs and actual pictures to provide greater coverage than is possible from a ground antenna. The pressurized plane has been modified for the purpose by Glenn L. Martin Company, flight and testing of the flying antenna will soon begin.



Jet Progress

Two Westinghouse jet engines, known as 19XB and 24C, have in the past year been adopted as power plants for several additional types of military aircraft. The 19-inch (diameter) engine briefly mentioned here a year ago is used on the McDonald Phantom, a high-speed Navy fighter designed for aircraft carrier service. It has also propelled the Douglas XB42A and is being applied to a Northrup flying wing. New and larger, the 24-inch model (shown on the back cover) with about 3000 pounds thrust (almost double the 1600 pounds of the 19-inch) is the power plant for at least nine experimental and production models of military ships. Among these are the Navy's two-engine McDonald "Banshee" and Chance-Vought "Pirate," and the Army's four-engine Curtiss-Wright heavy fighter (XP87).

During the year the 24C engine passed its 150-hour gruelling Navy qualification test that stamps it with official approval for aircraft builders to use. Specific performance figures are still withheld. However, the engine is acknowledged as the smallest in diameter or wind-drag area per unit of thrust of any in the world, attributable to its axial-flow compressor. Of engines now aloft, it is also one of the most efficient in pounds thrust per pound fuel, as well as the lightest in weight for its power. The light-load efficiency likewise is excellent. In actual flying it has proved to have those qualities that make it liked by pilots and maintenance crews. Combustors, often a critical component, have enjoyed extremely long life. Two 24C engines have each undergone 200 hours of wind-tunnel testing under a wide variety of conditions, such as high-altitude operation, icing, and tail burning. As this is written no planes flying with either the 19XB or 24C power plants have been lost because of engine failures.

Radar has been adapted from its military requirements of long-range "seeing" to the close-range work of peacetime marine navigation. It has been redesigned for simplicity in operation and control by the regular ship personnel, and for reliability in commercial service. Navigation radar has become a production-line product. Installations have been made on river boats, lake and harbor craft, and sea-going vessels.

The new automatic pilot uses a gyroscope sensitive to velocity instead of change of position. It is small and is insensitive to rapid accelerations.

That jet engines have come a long way from the temperamental creatures of early jet days (all of three and four years ago) is illustrated by the fact that the Banshee, during its first flight test, flew 50 hours without trouble up to its scheduled overhaul, a remarkable performance for any wholly new type of aircraft.

Engineers are justifiably proud of these two jet engines and their very creditable performance. Perhaps even more noteworthy, however, is the more general situation. Seven years ago there were in this country no jet engines or even any designs. In fact, neither were there designers to design nor plants to produce such engines. In these intervening few years a new and substantial industry has been fashioned. Corps of mostly young engineers were quickly called together during the darkest hours of the war when engineering talent was scarce. These men, almost strangers to each other and strangers to the device on which they were to work, were welded into a smooth-performing team and produced in a few months both designs and models of jet engines, the prototypes of present successful machines. Shop facilities, construction techniques, and workmen trained in this new art were concurrently established and brought to a point of smooth-running efficiency. This is in-

The new FM broadcast transmitters incorporate much of the experience and apparatus improvements that grew out of the enormous amount of radio development in wartime. This has resulted in transmitters compact, easy to install, simple to operate, extremely reliable, and of excellent appearance. Accessibility has been held paramount.

dicated by the fact that engines are being produced in quantity, on schedule, with return trips from test cell back to production floor for adjustments a rarity.

We have witnessed the birth in an astonishingly short time of a new industry. It is a credit to the versatility and technical skills of American men that such is possible. Engineers are now looking to the future. They have begun an extensive program of detailed refinement of the 24C engine and are working on a design for a new and much larger engine.

Floating Rides for Trains

SMOOTHER, faster, more comfortable train rides is the promise of a new railroad-car stabilizer. It has two jobs. One is to cut down the bounce—the inevitable but unpleasant up and down and sidewise movement of a spring-mounted car moving at normal speed even on smooth track, which, of course, has some irregularities. This is done by a set of active hydraulic shock absorbers that respond rapidly enough to wash out vertical and horizontal movement because it is controlled by small masses extremely sensitive to motion of the car body. A car that "bounces" four inches without the stabilizer moves only one inch with it.

Integrated with the shock absorber is an automatic banking device. It is a gyroscopic pendulum-controlled mechanism that tilts a fast-moving car the correct amount to compensate for each particular speed and curve. Aside from added comfort it gives, passengers will not have that unpleasant sensation of leaning or falling if the speed on a curve is faster than that for which the track is banked—it will permit faster speeds around curves. On lines through hilly terrain this will mean faster schedules, i.e., dollars to the railroad. Added to this is reduced wear and tear on the track, which means less maintenance. In conjunction with one of the largest railroads in the United States, trials are being made with a stabilizer on an actual passenger car in revenue service.

A New Wire Enamel

A BOON indeed to the electrical industry is wire enamel, the thin, one- to two-mil films of insulation used on millions of pounds of round copper conductors from no. 12 to no. 50 gauge. In fact, it is fast becoming the most important electrical insulation. More and more dependence is being placed on such films and great gains are in view as even better enamels are being developed.

Now on the way is a new synthetic enamel that promises further improvements over those presently used. It is approximately equivalent to the best mechanically, but is several times better than others in thermal stability. On very small wires in particular, where the film thickness is only a small fraction of a mil, it has shown far more uniform coverage and better ability to withstand high mechanical pressure between adjacent coils. It has excellent resistance to the power-

Dielectric heating is used in wood-forming plants, such as this one manufacturing radio cabinets, to cure the glue. No metal fastenings are employed. Below is a 100-kw heating generator.

ful solvents now used in insulating varnishes and is far the most resistant to Askarel of any enamel known, although experience is yet insufficient to recommend its use in such liquids. One enamel, now in production on small wire sizes from no. 22 to no. 42, has made an excellent record for most of a year. Results indicate that better insulations will be made as we learn more about how to build into them desirable properties by controlling molecular structure and processing of synthetic resins.

R-F Heating Today

In at least one case a multi-million dollar plant has been built with the product resting solidly on radio-frequency heating. Without this process this machinery plant, which uses electronic generators for induction-hardening of gears, shafts and similar machine parts, is inoperable because no provision has been made for alternative methods of heating. This is eloquent evidence of industry's confidence in induction and dielectric heating. In scores of plants throughout many industries r-f heating is the accepted production tool. Sets covering the range of ratings from 2 to 200 kw have become standard products and are being made in quantity, with the demand pressing productive capacity.

In the recent months dielectric heating has been put to work in the wood industry. It is, for example, making "big ones out of little ones." Big panels and timbers are made by edge-gluing small ones and dielectrically curing the glue, sometimes as a continuous process. The result is a utilization of small pieces of lumber, an increase in product strength, and reduction in overall cost of finished product. Cabinet makers are using it in place of metal fastenings. One radio cabinet maker is currently building a cabinet in which all 28 pieces are held together solely by dielectric-cured synthetic glue and forms the laminated curved front as a step in the process. The result is better appearance and the elimination of many steps in production with consequent savings in cost of manufacture.

The work-handling equipment to go with r-f heating systems is being well developed. Although each application presents problems of its own, the beginnings of a standard basic line of work-handling equipment are appearing in such components as sinks, quench mechanisms, scanning devices, and indexing tables. This is further increasing industry acceptance of r-f heating as a production tool.

Most interesting new trend seen on the dielectric heating horizon is the use of microwaves—radar frequencies. The early laboratory work with the use of such extremely high frequencies for heat-treating thin sheets, for curing thin synthetic films, for curing insulation on wire as a continuous process has been most promising. The techniques for this work are borrowed directly from radar and involve such radar components as magnetrons and waveguides.

Simulated Lightning, Night Flying Aid

Mountain-size problems require heroic solutions. How to effect safe landings of airplanes in all sorts of weather has been a problem of major magnitude. Many schemes involving lights, radio, and radar have been and are being considered. However, regardless of what radio and radar can eventually offer there never will be a perfect substitute for the pilot being able to see his landing strip. But to provide lights that will unmistakably indicate the landing area, regardless of ground visibility conditions, has been considered unattainable until recently. An entirely new system, tried on a small scale at the Cleveland Airport, has met with such complete success that there is now little doubt that an answer is possible.

The difficulty has been twofold: inadequacy of concept of the magnitude of the job and the lack of suitable light sources. Both have been short by several orders of

The Laundromat, (lower left) which is simplified by the reduction of controls from two dials to one, has a companion in an automatic electric drier. Joining the electric comforter is a new electric sheet that can be used as an ordinary sheet with any regular light blanket or conventional type of cover.

The krypton lamp, with greater surface brightness than the sun, is the heart of the all-weather approach lighting system of which one experimental unit is shown below.

magnitude. The scale of the job is enormous. Conditions ranging from clear moonlit nights to dense, ground-hugging, daytime fog, with a multiplicity of conditions of snow, rain, and fog thickness in between must be met in every instance with a visible glareless indication of the runway. The range in light intensities required is several million to one.

Out of war developments has come the missing light source—the sun-rivaling krypton lamp. This lamp is paired with special neon lamps to provide a wide selection of light indications from a faint trace for clear moonlit nights to simulated lightning strokes for heavy daytime fog.

The system is called All Weather Approach Lighting. It is made up of 72 light units consisting of 36 krypton and 36 neon or blaze units spaced alternately, all arranged in a single row extending outward from the front edge of the landing strip for three-fifths of a mile. For conditions of best visibility, only the blaze units are lighted at the lowest intensity (100 candlepower) continuously. The incoming pilot thereupon sees only a row of soft red dots, pointing to the runway. As visibility decreases the intensity of blaze units can be stepped up first to 1000 candlepower and then, if need be, to 10 000 candlepower. If visibility continues to worsen, the blaze units can be set to flash every second and a half with candlepower outputs of 100 000 or 10 000 000 as needed.

For conditions requiring still greater punch the kryptons, which meanwhile have been idle, swing into action. They too can be flashed at different brilliancies—up to 3.3 *billion* candlepower! The tube brightness can be controlled from a relatively low value to as much as nine million candlepower per square inch, which is nine times brighter than the sun as viewed from the earth's surface. The tube breaks down at about two thousand volts, which permits a peak discharge of about three million watts.

Each blaze unit is made up of six tubular lamps, each about two feet long and a half inch in diameter, fitted with special electrodes and filled with neon.

The 72 krypton and blaze lamps provide an approach-line lighting with the flexibility required to suit any visibility condition. The controls are synchronized so that, when in flashing service, the units are tripped successively, beginning at the far unit, each one firing before the one ahead appears to have been extinguished. This flashing is repeated 40 times per minute, so that to an incoming pilot the approach line appears as a streak of lightning of about three-hundredths second apparent duration running for three-fifths of a mile toward the runway and recurring every 1½ seconds. Radio and radar can be used to bring the plane within view of the flashes even in the worst weather.

Thus the approach line of lights provides a flexible system of light controllable in amount and with enough peak brightness to meet any condition. Yet at no time is the pilot subjected to blinding glare. Even if the lamps should be turned on full when visibility is good (a condition that would not happen in practice), the pilot is not blinded because the duration of the flashes is so short the eye does not even begin to respond to the great brightness. In actual tests the eyes, even though exposed to these bright lights, do not lose their dark sensitivity. In short, engineers have combined a little-known fact about the physiology of seeing and a war-developed krypton lamp to create a system that will go a long way in solving the aviator's worst remaining safety problem, that of landing aircraft safely in any weather.

More Serviceable Air Conditioners

THE single-package air-conditioning units used in small stores and offices must, in addition to being economical in operation, be as miserly of floor space as possible, quiet, of pleasing line, easy to install and service, and adaptable to the geography of the store. Designers of the new floor-mounted air conditioners have sought to combine to the maximum all these requirements—particularly those of installation and servicing.

The whole unit is mounted on a steel frame, to which the outside panels are attached on the site. This makes for easier handling and eliminates possible marring of the finish in shipment. Use of easily detachable front and side panels gives complete access to the mechanism from the front instead of moving it in order to work from the rear. By a relatively simple internal change the cooled air can be discharged from either the top or the front, as the location requires.

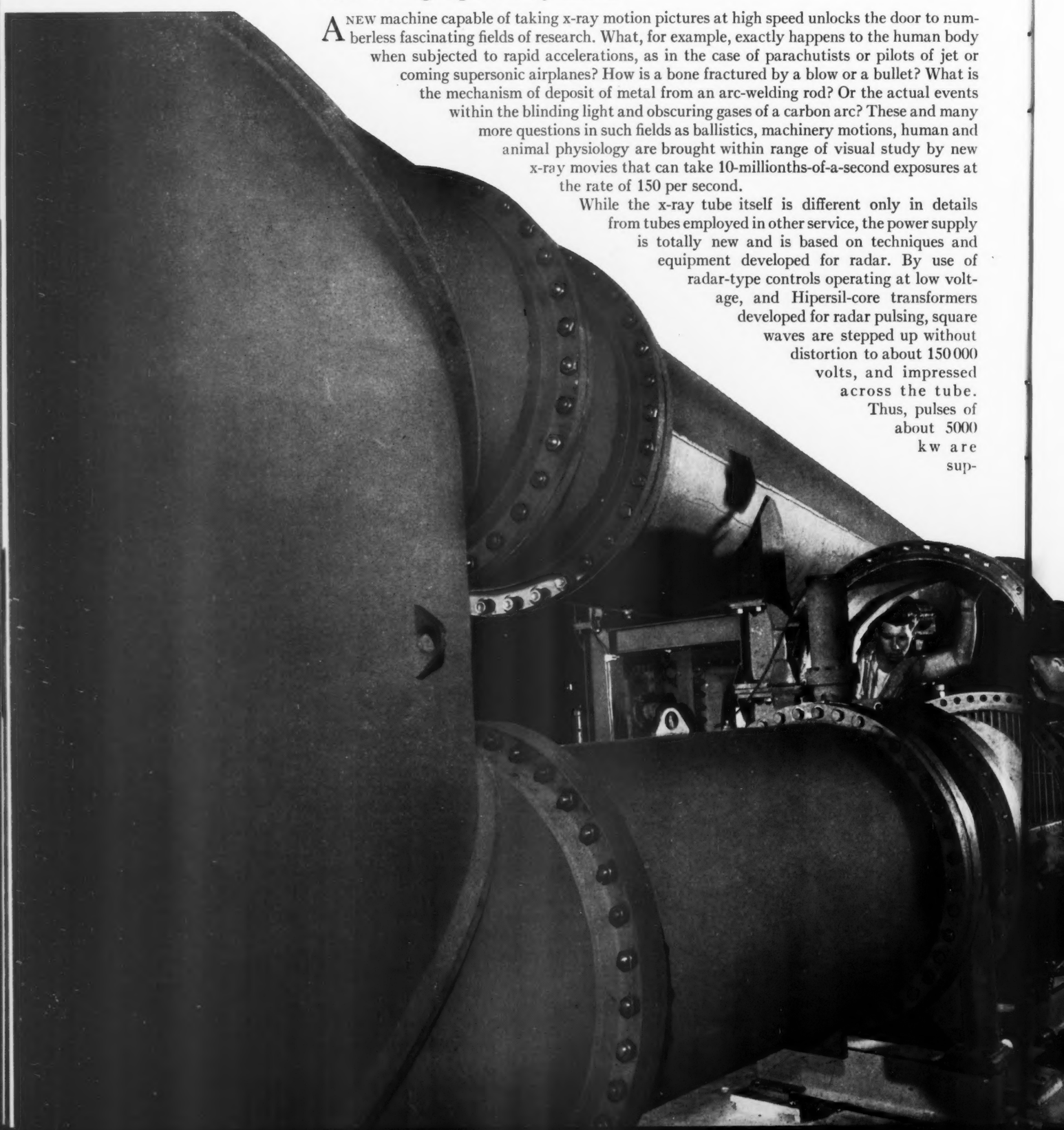
The compressor, condenser-receiver, and fan and motor assembly are all mounted on rubber. The fan shaft has rubber-housed bearings, and the fan motor is resilient mounted. To reduce fan outlet noise, the fan outlet is connected to the cooling plenum by means of a canvas duct, and the Unitaire is a "blow through" type rather than a "draw through" type with reference to the cooling coil. The entire cabinet is lined with sound-absorbing insulation.

Looking to the Future

Now It's High-Speed X-ray Movies

A NEW machine capable of taking x-ray motion pictures at high speed unlocks the door to numberless fascinating fields of research. What, for example, exactly happens to the human body when subjected to rapid accelerations, as in the case of parachutists or pilots of jet or coming supersonic airplanes? How is a bone fractured by a blow or a bullet? What is the mechanism of deposit of metal from an arc-welding rod? Or the actual events within the blinding light and obscuring gases of a carbon arc? These and many more questions in such fields as ballistics, machinery motions, human and animal physiology are brought within range of visual study by new x-ray movies that can take 10-millionths-of-a-second exposures at the rate of 150 per second.

While the x-ray tube itself is different only in details from tubes employed in other service, the power supply is totally new and is based on techniques and equipment developed for radar. By use of radar-type controls operating at low voltage, and Hipersil-core transformers developed for radar pulsing, square waves are stepped up without distortion to about 150 000 volts, and impressed across the tube. Thus, pulses of about 5000 kw are sup-



plied to the tube for about 10 microseconds every 1/150 of a second. This peak power is a thousand times greater than that ordinarily handled by x-ray tubes.

Metals, Rare Today, Common Tomorrow

RARE metals have a way of suddenly becoming engineeringly important after long peaceful periods as scientific curiosities. Uranium was like that. Zirconium appears to be following the same pattern, although it is unlikely to acquire such spectacular military significance. A more peaceful but important future seems at the moment to be indicated for zirconium, which is still in early stages of rare-metal evolution.

Like uranium and molybdenum, zirconium has been a metal little known outside such places as lamp-research laboratories. To adapt this metal for commercial use, it had to be produced in malleable form, highly desirable in commercial practice. This was followed by a relatively cheap process suitable for large-scale production. Malleable zirconium has been produced for several years in limited quantity at a cost of thirty to forty dollars per ounce, which has restricted its use although the metal has several interesting properties.

But zirconium is showing signs of breaking through the tight barriers. New and much cheaper ways have been found to produce it. One is the outcome of research aimed at betterment of electron tubes. The process starts with zirconium oxide, a fine white powder. The first step is to persuade the metal to divorce itself from oxygen. This is done by heating the oxide in an inert atmosphere with calcium and calcium chloride. While zirconium has a great fondness for oxygen, that of calcium is even greater, so that zirconium metal dust is precipitated. This can be pressed into blocks, heated to sintering temperature, and subsequently worked cold into desired shapes. Still another process involves magnesium in place of calcium and zirconium chloride instead of zirconium oxide. The end result is the same.

Throughout the preparation of metallic zirconium it must be carefully shielded from oxygen, nitrogen, and many other substances with which it readily combines. If exposed while hot to oxygen it absorbs the gas causing the product to be brittle and generally unworkable.

Its behavior as a sponge for oxygen, and similarly for nitrogen, gives zirconium its appeal to electron-tube engineers. Placed in a tube, a small quantity of the metal acts, as engineers picturesquely term it, as a "getter" to "clean up" stray oxygen or nitrogen molecules. These may appear during early life of the tube from within metal and glass parts and are destructive to normal functioning. Zirconium soaks up astonishing amounts of these gases and refuses to give them up even on prolonged heating. Zirconium likes hydrogen too, but is willing to release it when hot. This suggests the possibility of using zirconium in tubes that require a hydrogen-gas balance.

From a large new laboratory, built solely for jet-propulsion research, will come the basic knowledge for many of the jet units of the future. One of the most completely equipped laboratories in the world, it can separately test compressors, combustors, fuel systems, and gas turbines, for all conditions of load and simulated altitudes.

Zirconium is a moderately light metal, medium soft (about 80 to 150 Brinell, 40 to 80 Rockwell B) depending on the process used for manufacture. Although it absorbs oxygen in prodigious amounts it does not form an oxide at room temperatures. A white, silvery metal with a beautiful luster, it takes and permanently retains a high polish because it does not oxidize or combine with common corrosive gases such as sulphur. This immediately suggests its use in fine jewelry and even tableware, having the advantage over silver of never requiring a polish.

However, the day of such common uses is not yet. New processes, like those described, while they will reduce the cost to fewer dollars per pound than the present price per ounce, cannot bring it within range of mass use. But, the course has been started. Perhaps some day zirconiumware may be the gift for the June bride who will walk to the altar to receive a zirconium ring.

Exploring Fire

ENGINEERS are taking a close look at one of the oldest phenomena known to man—the flame. At East Pittsburgh a large, modern, expensive laboratory, well staffed by research engineers, is in operation just to study the mechanism of combustion, which for all its age and seeming simplicity still has many secrets. The answers to these are of vital importance to gas-turbine and jet-engine designers.

The research has numerous aspects. One has to do with flame propagation. Considerable research on rates of flame travel in combustion mixtures has been done elsewhere, but mostly at ordinary pressures—around atmospheric. But not much study has been made of propagation rates at low or high pressures. Curiously enough, flame travels relatively slowly through gases—say two to five feet per second, unless other factors are brought to bear. It is these other factors that are important. Ways of providing large flame areas, reverse flow, turbulence; effect of pressures, mixture temperatures, nature of fuel, its proportions with air are undergoing critical study particularly at gas pressures other than atmospheric.

Air flow in chambers burning light fuels is another subject of study. For example, should air come from behind the fuel nozzle? If so, how far behind? If in front, how far in front? Should air be injected radially? At an angle? With a swirling motion? What is the best configuration of air-inlet holes? It has already been found, for example, that large holes with relatively low air velocity provide a better combination of flow path and turbulence than small holes and high velocity.

Stability of flames is an important matter. It is desired in gas-turbine work, for example, that combustion occur in the wake of an object held in the stream of gases. The flame must neither be blown out nor allowed to creep behind the object and move upstream to the source of combustible mixtures. The factors effecting this stability are being analyzed.

One of the most immediately practical phases of combustion research is development of a combustion chamber in which heavy fuel, such as bunker C, can be burned. Here the problem was to develop a burner, small, efficient, with long life, free from carbon deposits and hot spots, in which the fuel could be ignited readily and reliably with a flame stable under a wide variety of loads.

The combustion chamber being used on the locomotive-type gas turbine is a very satisfactory result of this study. It

is a stepped nickel-chrome-steel tube 36 inches long and varying in diameter from 3 to 4½ inches. For its volume the heat release is enormous—about three million Btu per cubic foot per hour per atmosphere of pressure. The corresponding figure for steam boilers seldom exceeds 200 000, or one fifteenth as much. Although the flame temperatures run around 3500 degrees F the combustion-chamber sleeve remains at about 1000 degrees. This is accomplished by introducing cooling air between the stepped sections to maintain a protective blanket along the wall of the chamber.

An important contribution of the new laboratory to combustion is a new type of atomizer. By learning where to introduce air, in what direction, and at what pressure, a fuel spray is obtained that consists of much finer particles than is possible with previous air-atomizing nozzles—and, very importantly, it needs only about one fiftieth as much air flow, even for heavy fuels. The nozzle is particularly adapted to giving good, stable performance at starting and light-load conditions.

Among other important phases of present research is development of devices and techniques for accurately measuring temperature in combustion chambers. Another major field of research on which much has been accomplished is combustion of pulverized coals.

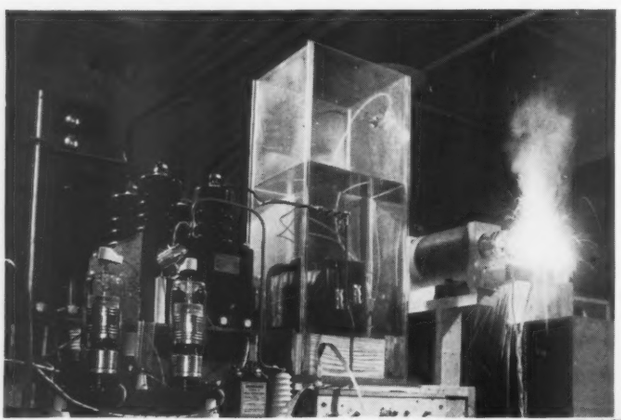
Super-Hot Furnaces

THERE is much talk about high temperatures in industry. But, far ahead of the necessary new temperature-resistant materials must proceed the advance guard, research, that requires furnaces capable of even greater heats. Illustrative of pioneering steps in advance of engineering utilization is a series of new research-laboratory furnaces.* One is capable of producing heats of 3100 degrees F (1700 degrees C), nearly 200 degrees F hotter than ordinary laboratory high-temperature furnaces. Also it has an effective heat zone of about four cubic feet, which means it can take a charge approximately four times larger than is customary.

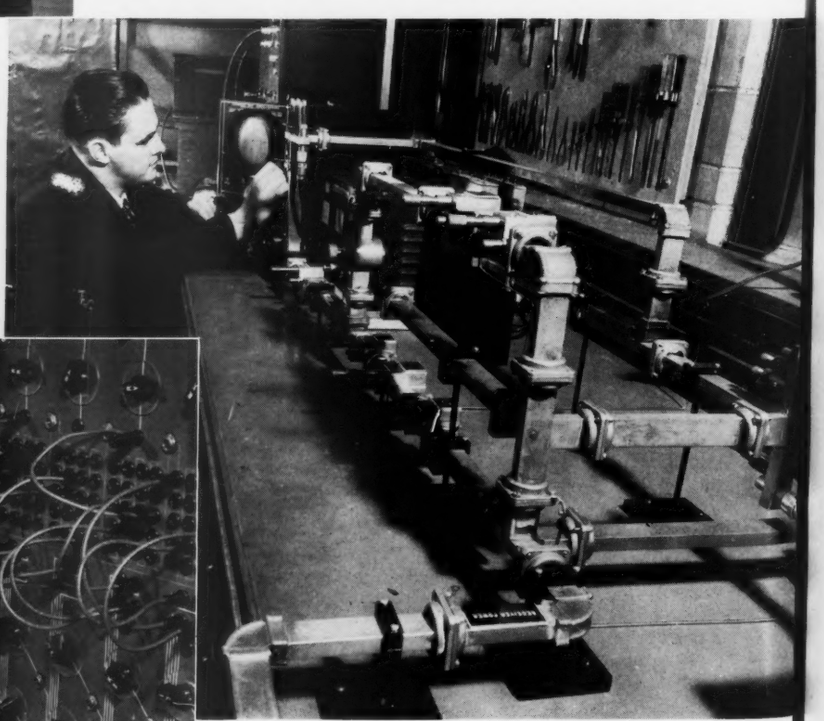
It is a radiant-type furnace, but instead of using heating elements consisting of fine wire coils wound on muffles, it uses less troublesome heavy molybdenum rod laid on ledges in the refractory brick. Incidentally, to produce these heating elements required molybdenum to molybdenum welds using atomic hydrogen, which was its first application to large pieces of molybdenum.

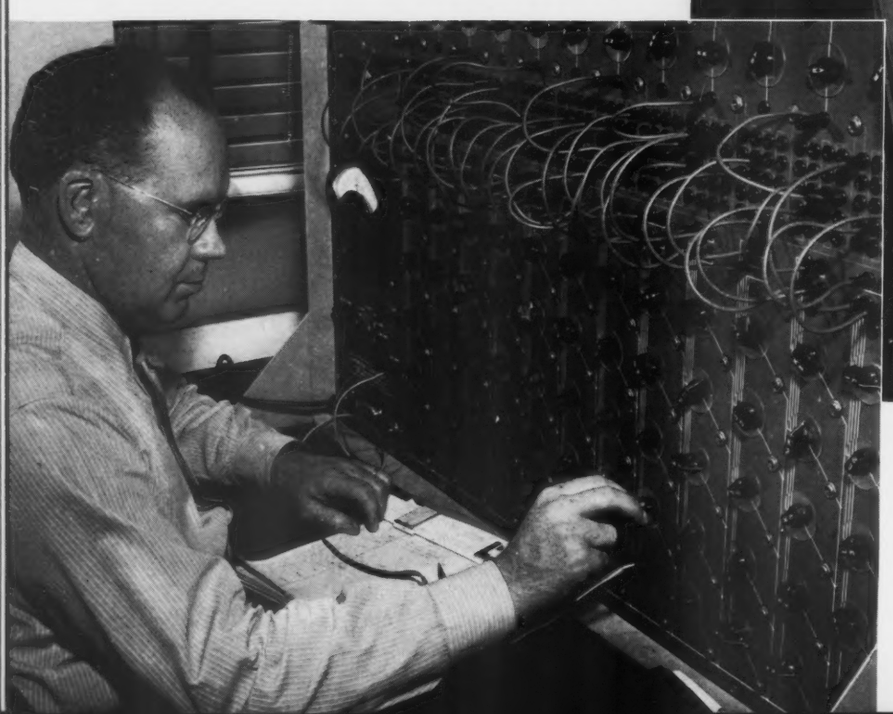
But 3100 degrees is just another step in high-temperature research. It is, by no means, the end sought. Another research furnace of the same general dimensions and principle is on its

*The furnaces were built solely for laboratory use. Commercial production is not planned for the near future.



Slow-motion pictures through steel or other opaque materials are possible with a new high-speed x-ray movie that takes 150 ten-microsecond exposures per second. The action of a small Thermit bomb is here being reduced to slow-motion. Below is the special calculator that can reduce the investigation of the numerous possible combinations of a low-voltage power system from many days to a few hours.





Above is the ultra-high-frequency "plumbing" used to investigate the possibility of radar to locate and track storms. Right center is one corner of a combustion laboratory to study fundamental problems of flame. At far right is a special laboratory furnace to provide temperatures up to 4700 degrees F

way. It is expected to produce laboratory temperatures of 3400 degrees F (2200 degrees C).

But 3400 degrees F is cold compared to the 4700 degrees F (2600 degrees C) sought in a still different but much smaller furnace. In it a tungsten crucible, large enough to hold a walnut, is heated in an inert gas by a combination of radiant heat and high-frequency induction. Temperatures approaching 5000 degrees F are really extreme. Tungsten itself begins to soften at about 4900 degrees F. Iron melts at 2795 degrees F; lava spews out of a volcano at 2200 degrees F. If research men must have higher temperatures they will be indeed hard put to find materials with which to make them or to take them. But it can be counted that research will require higher temperatures and that they will be forthcoming.

Plating Research on a Production Basis

THE keynote of a new plating laboratory being assembled at East Pittsburgh is "speed-up electroplating and corrosion research." Toward this end the laboratory is being set up to employ standardized procedures, specimens, and records and thereby put the solution of each problem on a production-line basis as far as possible.

The backbone of the laboratory consists of three separate plating lines. The first two are primarily for research and development. Here processes are started in small cells. Next is a continuous table of 20 four-gallon tanks, 10 on each side with a reagent stand in the center, where the process is repeated on a larger scale. Once the research and development lines have done their work, the problem is shifted to the last phase, the pilot line, which consists of nine 100-gallon tanks in the form of a pilot plant, where actual small-scale production will be undertaken. Once a process leaves the laboratory it will be ready for efficient factory production with a minimum of "bugs" to be ironed out.

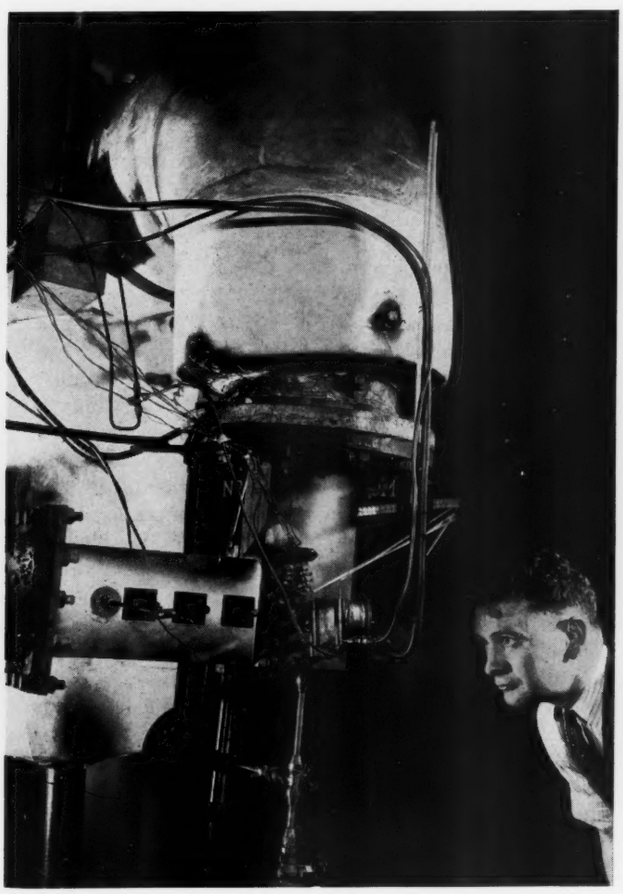
Maintenance around plating installations is usually high due to the corrosive action of chemicals and fumes. By making the laboratory as maintenance-free as possible, lost time is minimized. Corrosion-resistant materials are used everywhere —in the tanks, work benches, drain pipes, and even on the ceiling, floors, and walls.

Close control of all experimental and production work is made possible through the use of automatic voltage regulators, deionized water (which is becoming more common in commercial production work), control of electrostatically cleaned air temperature and humidity, and by individual temperature and agitation control of the solution in each development and pilot tank. Covers over all exposed piping and spaces between pilot tanks give the laboratory a smooth, efficient appearance.

The laboratory is made self-sufficient as far as possible by facilities for buffing, paint spraying, microscopic analysis, and for testing the quality of the product under varying conditions of heat, humidity, and salt-fog atmospheres. Ample space in a simple, efficiently organized storeroom make it easy to find tools, instruments, glassware, chemicals and the other multitudinous accessories so necessary for efficient use of laboratory time.

Laying the Groundwork for Extra-High Voltages

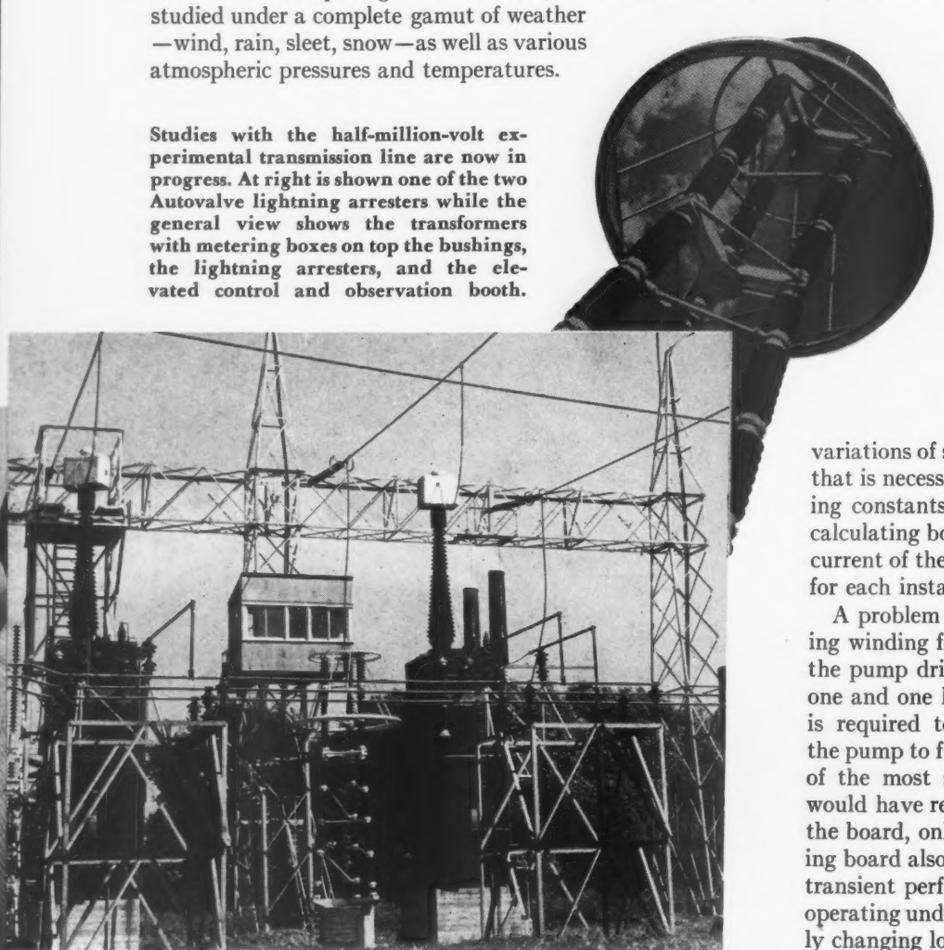
IN a valley bordering on the banks of the Ohio River, a few miles below Steubenville, is the oddest high-voltage transmission system ever built. The towers are the largest and the



lines the shortest. Certainly it is for the highest voltage ever attempted—one-half million, nearly double the present operating maximum.

The system comprises three lines. Two are each a mile and a half long. The third is even shorter, a single span between two towers. The lines at the substation end are connected without benefit of circuit breakers directly to the highest voltage power transformers ever built, protected by lightning arresters of similar record-setting rating. The far ends of the lines are open and will never carry more than charging current.

While these lines don't go anywhere, they will lead to answers that must be had before high-voltage transmission can move above its present ceiling of 287 kv into the realm of extra-high voltages. Constructing lines for higher voltage is not just a matter of proportionately increasing the dimensions of towers, conductors, and porcelain. Neither is it a matter of devising adequate lightning protection, for lightning is no longer the bete noire of transmission engineers. The obstacles have to do with power limit or the maximum amount of power that can be transported over a given line. It is in achieving the maximum power limit that the engineer finds himself betwixt conflicting demands. Minimum impedance, which has a direct bearing on power limit, requires the smallest feasible conductor spacing. Avoidance of corona, on the other hand, requires wide separation of conductors—which entails high-cost construction. Many factors that affect these and which cannot be extrapolated from known data and present experience will be studied on these full-size lines. These include different types and diameters of conductors, divided conductors, various conductor spacings. Furthermore, all of these can be studied under a complete gamut of weather—wind, rain, sleet, snow—as well as various atmospheric pressures and temperatures.



Studies with the half-million-volt experimental transmission line are now in progress. At right is shown one of the two Autovalve lightning arresters while the general view shows the transformers with metering boxes on top the bushings, the lightning arresters, and the elevated control and observation booth.

The test program is being conducted by American Gas and Electric Service Corporation and the Ohio Power Company, its affiliate, on whose system the lines were built, with the cooperation of several manufacturers. Westinghouse supplied all the necessary high-voltage electrical apparatus—lightning arresters, transformers, and special metering equipment and has been active in planning the investigation. Both the arresters and transformers follow design and construction principles employed by Westinghouse on conventional lower voltage equipment.

The studies, which began in October and will continue for many months, will provide the engineering knowledge for future higher voltage lines by which cost of power transmission and hence cost to the user can be reduced.

Engineering Made Easier

CALCULATING devices have come a long way since the invention of the abacus by an unknown Asiatic. New ones for special purposes are continually bobbing up. Two of last year's crop are representative. One is to help plan banked-secondary or industrial-network power-distribution systems. The other helps determine the proper winding to use in a synchronous motor for a given job.

When more than one transformer supplies power to low-voltage systems calculation of voltages and divisions of current for different combinations of load and points of power supply becomes tedious and time consuming. Using the network calculator, the time to explore a proposed distribution system has been reduced from days to hours. But more important than the specific time saving is the fact that because of ease of exploration all possible combinations can be examined and the best one found with surety.

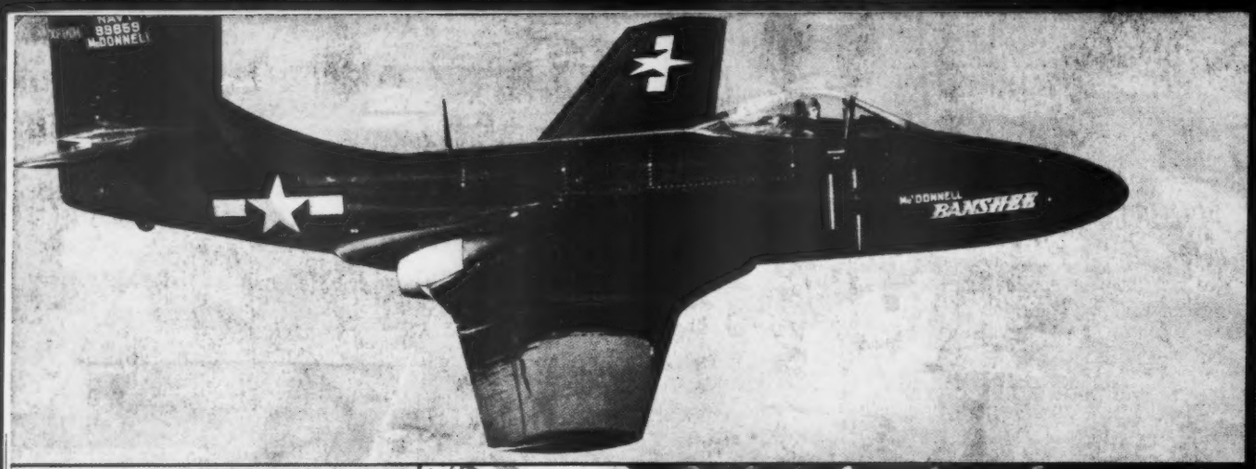
The calculator is an adaptation of the direct-current calculating board developed a quarter century ago. Resistances representing transformers, line drops, loads, and even short-circuits, if desired, are quickly connected in various possible combinations. When energy is introduced at proper points current and voltage readings throughout the network can be taken simply by reading the instruments.

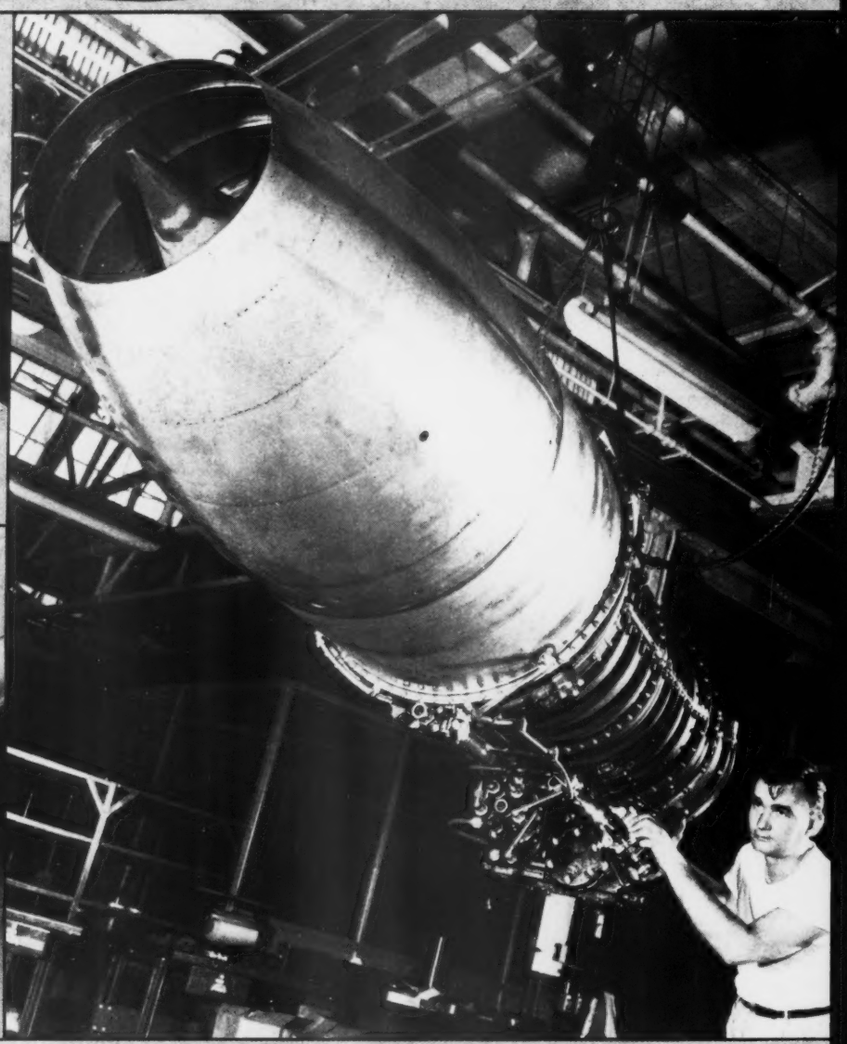
The synchronous-motor calculator, employing similar principles, cuts to a third or less the time required to calculate the dozen or more variations of starting windings for some special condition. All that is necessary is to determine several sets of starting winding constants for the motor, insert each set in turn on the calculating board, and torque, line current, and induced field current of the proposed motor can be read on built-in meters for each instant from starting to full synchronous speed.

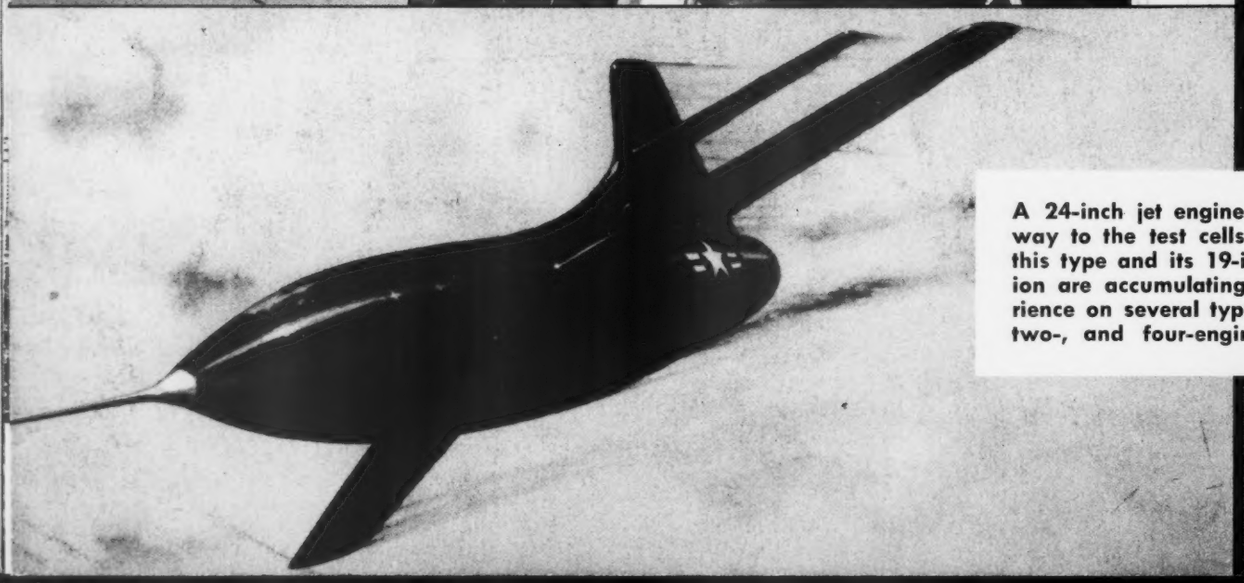
A problem recently encountered was to design the starting winding for a pump motor. When no power is delivered, the pump drives the motor backwards at a speed equal to one and one half times its rated forward speed. The motor is required to stop the backwards motion and accelerate the pump to full forward speed within a given time. Selection of the most suitable winding for such unusual conditions would have required over forty hours for calculation. Using the board, only thirteen hours were necessary. The calculating board also reduces the time to determine accurately the transient performance of synchronous motors and generators operating under such conditions as reciprocating or constantly changing loads

LAST but not least.....

HERE we are, out of pages, with many things left unsaid. Remaining among our notes are numerous developments we consider interesting. We had hoped to tell, for example, about the distribution system going underground in southern Florida, both for the sake of appearance and to escape high winds that torment pole lines and overhead structures and sometimes disrupt service. . . . Another underground installation being watched with interest consists of a pair of dry-type network transformers completely sealed in a nitrogen atmosphere. Fireproof and explosionproof, they will require the minimum of maintenance . . . Electric stairways will no longer be so exclusive. Customarily associated with large multi-floor department stores and transportation terminals, an electric stairway is now being produced just for small retail stores, banks, and restaurants—establishments with but two or three floors. It employs standardized features and production-line methods to achieve low cost, light weight, compactness . . . We like the idea of the enterprising, public-relations-minded theater owner who placed infrared heat lamps under the marquee to keep customers warm while they wait in line for tickets . . . Store owners are considering the same idea to attract window shoppers . . . Another new use of infrared is to remove paint. More convenient than a blowtorch. Safer, too . . . There's the so-called Booster Button on the new electric water heater. By pushing it on washday or when a short-time need for extra hot water appears, water is heated to 170 degrees F instead of the usual 150 degrees. In effect it increases hot water available by about 20 percent. Automatically resets for normal temperature . . . Progress with the experimental locomotive-type gas turbine should be cited. By late fall it had chalked up over 600 hours of operation, about half in simulated railroad service. No troublesome creep or distortion has appeared, although the full 1350 degrees has been reached. Another facet to gas-turbine development is the addition of a solids-fuel department to the Westinghouse combustion laboratory. Research on combustion of coal pulverized to various degrees of fineness will reveal the mechanisms of combustion and the relationships between particle sizes of coal and fly ash . . . "Out of sight out of mind" may be good policy for the maid as she sweeps dirt under the rug. But eventually it will catch up with her. So, too, the underside of outdoor switchgear, power centers, and other cabinets if not given some corrosion protection. They are getting it now —from tough, moisture-resistant, rubberized coatings. . . . Spectacular new way of debarking logs faster is with high-pressure jets of water. There are two general schemes. In one the log passes through a ring with inwardly directed jets; in the other, it is turned as in a lathe, the jet acting like a cutting tool. Special controls are required, and big motors to drive pumps that deliver water at pressures up to 1250 pounds per square inch . . . Another "largest" has appeared in high-speed synchronous motors. This one, 10 000 hp, 3600 rpm, drives two Sturtevant blowers, one on each end, to deliver air at 7 psi pressure for testing ram-jet engines . . . The Lifeline motor tree was, a year ago, but a sturdy trunk consisting of basic polyphase squirrel-cage induction motors. It has since put out many, many branches—for non-standard voltages and frequencies, for special torque requirements as with punch presses and hoists, and for reluctance-type synchronous motors as used on balancing machines. Lifeline ideas are now being extended also to wound-rotor motors. . . New d-c motor embodies many features of a-c Lifelines—no castings, all steel. Covers snap into position like automobile hub caps. Absence of screws improves appearance. Bearings are prelubricated, sealed . . . Hydrogen-cooling systems for turbine generators are being simplified by a redesign of the shaft seal. Now it will be easier to eliminate air and hydrogen absorbed by sealing oil . . . An improved pressure-relief device for tanks of power transformers uses a bellows arrangement and a trigger-like release of a cover instead of a glass or plastic diaphragm that blows out when pressure gets too great. It can be set for lower pressures, much more precisely calibrated, and follows rapid pressure rises. . . Nor did we get around to saying much about the new laboratories so essential to insure a large crop of developments tomorrow. There is the four-engine mock-up on which new electrical systems for future big planes are tried in detail. A half-mile section of city street is set aside as a practical street-lighting laboratory. The Research Laboratories have their Operation Ultra-Frigid. Study of the effects of temperature on materials and their electrical conductivities will be possible in a room where temperatures can be dropped to within one degree absolute . . . Subway cars are getting up in the world, even though they remain underground. Fluorescent lamps, powered by a flywheel-stabilized m-g set, will permit you to read, without squinting, your newspaper or the "ads" even when passing over a third-rail gap. Four spring-suspended, 100-hp motors instead of the usual two 200-hp and smoother acceleration and deceleration will provide a more comfortable ride even when standing. A new-type ventilating system supplying Precipitron-cleaned air will leave you with a "home was never like this" feeling . . . And now we are out of space for sure.







A 24-inch jet engine starts on its way to the test cells. Engines of this type and its 19-inch companion are accumulating flight experience on several types of single-, two-, and four-engine airplanes.